Status Survey and Conservation Action Plan

Wild Cats

Compiled and edited by
Kristin Nowell and Peter Jackson

IUCN/SSC Cat Specialist Group

IUCN
The World Conservation Union

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Species Survival Commission

CAT SPECIALIST GROUP

Sultanate of Oman

Chicago Zoological Society

WWF

Conservation International

IUCN/Species Survival Commission Conservation Communications Fund and Contributors to *Wild Cats*

In 1992, IUCN's Species Survival Commission established the Conservation Communications Fund to garner support for its expansive Publications Programme which promotes conservation by: (1) providing objective scientific information about biodiversity, habitats, and ecosystems; (2) identifying high priority actions for conservation; and (3) delivering the information and recommendations to natural resource managers, decision-makers, and others whose actions affect the conservation of biodiversity.

The SSC's Action Plans (*Wild Cats* is #28 in the series), Occasional Papers, newsletter (*Species*), membership directory, and other publications are supported by a wide variety of generous donors (see below):

The Sultanate of Oman established the Peter Scott IUCN/SSC Action Plan Fund in 1990. The Fund supports Action Plan development and implementation; to date, more than 80 grants have been made from the Fund to Specialist Groups. As a result, the Action Plan Programme has progressed at an accelerated level and the network has grown and matured significantly. The SSC is grateful to the Sultanate of Oman for its confidence in and support for species conservation worldwide.

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The National Wildlife Federation (NWF) makes a significant annual contribution to the SSC Conservation Communications Fund, in addition to grants for *in situ* conservation coordinated by the SSC. NWF is the largest non-governmental, non-profit conservation-education and advocacy organization in the United States. It emphasizes assisting individuals and organizations of all cultures, in the United States and abroad, to conserve wildlife and other natural resources and to protect the earth's environment to assure a peaceful, equitable, and sustainable future.

The World Wide Fund for Nature (WWF) provides significant annual operating support to the SSC. WWF's contribution supports the SSC's minimal infrastructure and helps ensure that the voluntary network and Publications Programme are adequately supported. WWF aims to conserve nature and ecological processes by: (1) preserving genetic, species, and ecosystem diversity; (2) ensuring that the use of renewable natural resources is sustainable both now and in the longer term; and (3) promoting actions to reduce pollution and the wasteful exploitation and consumption of resources and energy. WWF is one of the world's largest independent conservation organizations, with a network of national organizations and associates around the world and over 5.2 million regular supporters. WWF continues to be known as World Wildlife Fund in Canada and in the United States of America.

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Contents

Foreword

It is indeed an honor to write a foreword for a book of this stature—a more comprehensive work than this is hard to imagine, and a more welcome addition to the store of information on the cat family would be impossible to find. With this work the authors have set a new standard of scholarship for studies of the cat family. The level of scholarship presented here, as this work clearly shows, is quite obviously nothing less than the finest and most meticulous.

The aim of the authors is a high one—keeping a tradition of learning that began with compiling data upon the various genera of plants and animals of the different continents (I recall a massive multi-volume work entitled *The Lemons and Limes of Siam*), a tradition that came into its own in 1964 with the publication of Ernest P. Walker's *Mammals of the World.* The authors have included within a single work the entire spectrum of factual literature on the biology, ecology, distribution, and conservation status of each member of the cat family, presented in summary form, providing a comprehensive overview of these fascinating animals so that conservationists now and in the future will have a ready reference. Whether a reader is looking for bibliography on a species, the names by which a certain cat is known in local dialects, the use to which a cheetah puts his dew claws, the impact of the fur trade on the Brazilian jaguar population, or the likely impact of new Spanish highways on the Iberian lynx population, they will find what they seek in these pages.

The 1,500 references included here comprise a literature that begins with Marco Polo in the 13th century and extends to the present, and that must represent no less than 5,000 scholar/years of collective effort by various authors. Until the completion of *Wild Cats* such a literature could only have been found by combing libraries throughout the world. Conservationists in far corners of the world lack the resources to make those searches. But now, the authors of *Wild Cats* have done it for them.

Only a deep and abiding dedication to the cat tribe could possibly inspire such a magnificent effort, so to an aficionado such as myself, this book is mouthwatering. *Here it is,* you say to yourself as you open the pages with reverent anticipation, *Here it all is.* And sure enough, one need only to let the book fall open for something to spring off the page—from the (to me) grim report that the trophy hunting of lions by sportsmen brings twice as much income to a certain African country as can be derived from the viewing of lions by tourists in the national parks, to the perils awaiting those who would attempt to identify individual mountain lions by their tracks, to the tantalizing fact that rusty-spotted cats sometimes keep their kittens in the attics of houses set in rice fields, and that African golden cats, which have never been studied but are known to inhabit rain forests, may include as prey small primates who fall from the trees and lie injured on the ground. Such observations, anecdotal and fragmented though they may be, are nevertheless precious for two reasons: first, their very existence makes it clear that if we don't preserve the species, these passing observations may provide the only knowledge we'll ever have; and second, as a whiff of salt air suggests the ocean: tiny bits of information, however incomplete, suggest an entire lifestyle, in all its complexity, of animals that at this point we know little about, and that the vast majority of us will surely never see.

The mass of data assembled by the authors is analyzed to present general principles of conservation giving a clear sense of where the priorities for future conservation lie. These are summarized at the end of each of the Major Issues chapters. The Action Plan itself (Part III) translates the principles into concrete action—these projects should be carried out in the 1990s to improve the conservation of vulnerable cat species.

But the most important contribution that a book on any animal can make is to the future of its subject. Time is getting short for many of the cats discussed here. In particular, the big cats—tigers, lions, leopards, jaguars, snow leopards, and cheetahs—face the hostility of farmers because of real and perceived threats to livestock and, sometimes, people. These cats are often killed indiscriminately and their future outside well-protected areas is in serious jeopardy. In one of the most important chapters of this book, Kristin Nowell and Peter Jackson review the situation and discuss measures to minimize livestock predation so that big cats outside protected areas can co-exist with people. This is of vital importance because most reserves are far too small to accommodate viable big cat populations with a good long-term chance of survival.

A new and grave threat, with ancient roots, is the hunting of tigers and other big cats for bones for traditional medicine in China and elsewhere in Asia. This is causing a marked decline in tiger numbers, and in late 1992, Peter Jackson predicted that, unless current trends were sharply reversed, the tiger faced virtual extinction in the wild within a decade. Since then it is estimated that, in India alone, over 600 tigers have been poached, while, in Russia, Siberian tigers have been reduced from around 300 to fewer than 200. Large numbers of contraband skins and bones have been seized, but they can only be the tip of the iceberg.

Wild cats should not be seen merely as beautiful, but of little practical value. The cats are part of the web of life, the mutual interaction of animals and plants, which underpins human life on Planet Earth.

By its very existence this marvellous work seems to echo Walker's words in *Mammals of the World,* to whom the great biologist dedicated his enterprise. "To the mammals, great and small," he wrote, "who contribute so much to the welfare and happiness of man, another mammal, but receive so little in return, except blame, abuse, and extermination."

Here, in the hands of Kristin Nowell, Peter Jackson, and the IUCN/SSC Cat Specialist Group, the cat family is at last well-served.

Elizabeth Marshall Thomas

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Introduction

The Cat Action Plan

Wild Cats: Status Survey and Conservation Action Plan consists of a review and analysis of information relevant to the conservation of wild cats, and a priority action program. Part I provides summaries of the biology, ecology, distribution, and conservation status of each cat species. These Species Accounts are organized under five geopolitical regions: Sub-Saharan Africa, North Africa and southwest Asia, Tropical Asia, Eurasia, and the Americas. Part II examines the major issues pertinent to the conservation of all cats: habitat loss, management of big cats near people, research, trade, cats in captivity, and reintroduction. Parts I and II together form a comprehensive reference for people interested in cats and their conservation. The information contained within is a demonstration of the work of cat specialists, and it is hoped that the rich and multi-faceted picture of cats and their conservation which emerges will stimulate more people to become active on behalf of the wild cats.

Wild Cats is more, however, than an authoritative reference work. It is a strategic planning document which prescribes methods for making cat conservation more effective. These principles of cat conservation, which can be drawn from the text, prioritize conservation action on both international and regional levels. The principles also serve as a framework to aid local authorities in planning their own cat conservation priorities.

Part III, the Action Plan itself, presents 105 projects that build on the data and recommendations presented previously, and focus the general principles of cat conservation. Drawn up by the Cat Specialist Group, they concentrate on the most vulnerable species and are priorities for cat conservation in the 1990s. Implementation of these projects forms the mission of the Cat Specialist Group over the coming decade. If these projects realize their objectives, the family Felidae should enter the 21st century in good shape.

The priority projects listed in the Action Plan, for the most part, are in need of (1) financial support and (2) researchers and others to work on them. Those interested in funding, carrying out, or helping with any of these projects should contact the Vice Chairman, Projects for details: Kristin Nowell, 2520-4, 41st St. NW, Washington DC 20007, U.S.A.

An Executive Summary of *Wild Cats* prefaces Part I. In addition, the "Major Issues" chapters of Part II end in short summary sections which outline key points. A regional index to species vulnerability, which generally indicates species conservation priority, prefaces each regional chapter in Part I, the Species Accounts. The introduction to the Species Accounts explains how species vulnerability is ranked. Part III, the Action Plan, is organized according to the topics examined in Part II and the species order of Part I.

The Cat Specialist Group

The IUCN/SSC Cat Specialist Group is the world's premier body of scientific and practical expertise on wild cats and their conservation. Over 160 members (see Appendix 5) represent 50 countries and include field biologists, wildlife managers, government officials, leaders of non-governmental organizations which focus on cat conservation, and other specialists from diverse but interrelated fields including taxonomy, genetics, environmental law, wildlife trade and use, conservation education and wildlife photography, small population biology and captive breeding, and wildlife veterinary medicine. These people serve as Cat Specialist Group members in their personal capacities, but bring with them the experience and the knowledge gained in their professional careers. They volunteer the best of their thinking, and also, in many cases, their time and services, for cat conservation. This document represents the Group's first major collective effort to review what has been accomplished in the past, and to prepare a strategic plan for future action.

Through its members, the Cat Specialist Group maintains a substantial collective library. The Group plans to consolidate and disseminate this resource by establishing a Cat Conservation Data Center (see priority project in Part III). The Chairman publishes a biannual newsletter, *Cat News*, which is circulated to members of the group. It is available to anyone else who makes an annual donation to a special fund in the name of "Friends of the Cat Group."

For more information about the Cat Specialist Group, contact: Peter Jackson, Chairman, IUCN/SSC Cat Specialist Group, Route des Macherettes, 1172 Bougy-Villars, Switzerland, Tel + Fax: +41 (21) 808 6012, email: peterjackson@gn.apc.org or c/o the Species Survival Commission, IUCN —The World Conservation Union, 1196 Gland, Switzerland, Tel: +41 (22) 999 0001, Fax: +41 (22) 999 0015, email: mgd@hq.iucn.ch (attn jackson).

Executive Summary

Wild Cats: Status Survey and Conservation Action Plan

There are 36 species of wild cat, ranging in size from the tiger to the tiny rusty-spotted cat. They are found in every continent except Australia and Antarctica. This document, *Wild Cats: Status Survey and Conservation Action Plan*, is designed to promote the conservation of all the wild cats in their natural surroundings. The increase in numbers of people, the spread of settlement and the exploitation of natural resources of wild lands hitherto little disturbed, together with persecution, are threatening some cats with extinction. Other cat species are declining in numbers.

To assess the vulnerability of the cats, a system has been developed to rank them in five main categories, both on a world basis and a regional basis. The ranking system is based on four factors:

1. The number of habitat types with which each species is associated: the fewer habitats with which a species is associated, the more vulnerable it is to habitat loss.
2. Total range size: the smaller the distribution of a species, the more vulnerable it is to further loss of range.
3. Body size, which provides a link to estimates of total numbers: the larger the cat, the fewer the number of individuals likely to be located in a given area compared with smaller cats.
4. Active Threat ("A"), which refers to high levels of hunting pressure, leading to the loss of animals from habitat in which they would otherwise be present.

Combining the scoring on these factors makes it possible to group cats into categories in order of their priority for conservation (Boxes 1 and 2). The ranking system is described in detail in the introduction to Part I.

In general, species in Category 1 warrant first attention, both globally and regionally. Yet practical considerations play a large role in determining how conservation action should be structured in terms of projects. For example, the Iberian lynx emerges as the most vulnerable wild cat and is ranked ahead of the tiger, although the tiger is seriously threatened. However, it will take much more conservation effort to save the tiger than the Iberian lynx. The total numbers of Iberian lynx may be fewer than tiger, but the lynx occurs mainly in Spain, and this allows for unified conservation action. The tiger is scattered in small, localized populations in 14 Asian countries, including the world's two most densely populated nations, India and China. Moreover, the primary threat facing the tiger is illegal trade in tiger bone for Asian traditional medicines, and this calls for expertise in several fields: protection of key populations in reserves; protection of tigers outside reserves; analysis of the consumer market for tiger bone; and effective enforcement of both national and international trade bans. This explains why more priority projects are proposed for the tiger (14) than for the Iberian lynx (3) in the Action Plan.

For many of the most vulnerable small cats, there is little knowledge of their biology and ecology. Conservation of these species will be difficult without this baseline information. There are thus relatively few projects for these species beyond basic studies of natural history and detailed surveys of the distribution of sub-populations.

Part I: Species Accounts

The Species Accounts provide the latest information on the biology, ecology and conservation status of the wild cats. Photographs illustrate the characteristics of each cat, and maps provide the latest information on their range. The species accounts serve as a database, to be built on as research produces more information.

Part II: Major Issues in Cat Conservation

Part II is devoted to the review and analysis of six major issues in cat conservation:

Chapter 1. Habitat loss and fragmentation
Chapter 2. Management of big cats near people
Chapter 3. Research
Chapter 4. Trade
Chapter 5. Captive breeding
Chapter 6. Reintroduction

Examination of these issues leads to several inter-related conclusions about cat conservation, which are summarized at the end of each chapter. These are reviewed in this Executive Summary in the form of key general questions which the Action Plan projects are designed to answer.

How do cat species adapt to different forms of habitat loss and modification?

Chapter 1 shows that most of the world's original natural vegetation has been modified in some way by people. Protected areas cover only small portions of the range of most species, so that most cats live in modified habitat. Fortunately, cats, not having specific vegetation requirements, are more flexible than many other animals in terms

Box 1
Global Ranking of Cat Species Vulnerability

Category 1 (Top priority)	
Iberian lynx	*Lynx pardinus*
Category 2	
Tiger (A)	*Panthera tigris*
Snow leopard (A)	*Uncia uncia*
Bornean bay cat	*Catopuma badia*
Chinese mountain cat	*Felis bieti*
Black-footed cat	*Felis nigripes*
Kodkod	*Oncifelis guigna*
Andean mountain cat	*Oreailurus jacobitus*
Flat-headed cat	*Prionailurus planiceps*
Fishing cat	*Prionailurus viverrinus*
African golden cat	*Profelis aurata*
Category 3	
Cheetah (A)	*Acinonyx jubatus*
Lion (A)	*Panthera leo*
Jaguar (A)	*Panthera onca*
Asiatic golden cat	*Catopuma temmincki*
Oncilla	*Leopardus tigrinus*
Rusty-spotted cat	*Prionailurus rubiginosus*
Clouded leopard	*Neofelis nebulosa*
Marbled cat	*Pardofelis marmorata*
Category 4	
Sand cat	*Felis margarita*
Margay	*Leopardus wiedi*
Serval	*Leptailurus serval*
Canada lynx	*Lynx canadensis*
Geoffroy's cat	*Oncifelis geoffroyi*
Manul	*Otocolobus manul*
Category 5a	
Puma (A)	*Puma concolor*
Leopard (A)	*Panthera pardus*
Ocelot	*Leopardus pardalis*
Eurasian lynx	*Lynx lynx*
Bobcat	*Lynx rufus*
Pampas cat	*Oncifelis colocolo*
Category 5b	
Caracal	*Caracal caracal*
Jungle cat	*Felis chaus*
Leopard cat	*Prionailurus bengalensis*
Category 5c	
Wildcat	*Felis silvestris*
Jaguarundi	*Herpailurus yaguarondi*

A=Actively Threatened
(High levels of hunting pressure)

See pages 2-6 for explanation of vulnerability ranking system.

of their ability to persist. For example, logging in tropical rain forest does not necessarily lead to the decline or extirpation of its cat populations. As discussed in Chapter 3, there have been relatively few studies of cats in altered habitats; most have been done in protected areas. Several Action Plan projects (numbers 2 and 23) have been designed to identify the variables which permit cats to persist in different forms of modified habitat. In addition, a number of natural history studies are proposed which should be carried out both in good-quality protected habitat and in a type of modified habitat which predominates within the range of the species. It is important for these studies to estimate cat densities in modified habitat, so as to calculate numbers over large areas of their ranges.

Which types of habitat are most important for cat species conservation?
Certain habitat types are the richest in vulnerable cat species, but are either declining in area or becoming fragmented. These include tropical moist forest, especially in the lowlands, tropical montane complexes, high alpine habitat, and major wetlands. Conservation of these habitat types is important for cat species. Protected areas need to be sufficiently large to support viable populations of the biggest cats.

What management measures can be taken to promote conservation of big cats living near people?
Most cats are found outside protected areas, and live near people. They risk extirpation through unsuitable modification of their habitat, depletion of their prey, and persecution. This is particularly true for big cats, which can cause significant economic losses when they prey on livestock, particularly for poor owners of a few animals. Several Action Plan projects focus on the study of big cats which live among people, and on the recommendation and implementation of effective management measures (Projects 5, 6, 22, 23, 31, 32, 40, 51, 52, 71, 74, 75, 93, and 102).

What are the biological and ecological requirements of vulnerable cat species?
To evaluate the conservation status of cat species on a national or regional scale, a basic understanding of their biology and ecology is needed. Otherwise, it is difficult to plan specific conservation measures. For a surprisingly high number of vulnerable species, natural history has never been studied, either in detail or at all. A number of Action Plan projects have been put forward to address these major gaps in our knowledge of the cat family (Projects 2, 18, 20, 34, 37, 42, 43, 57, 58, 60, 61, 63, 64, 66, 68, 76, 77, 91, 92, 94, 96, and 99). In addition, long-term studies which have gathered comprehensive baseline data on cat populations should be continued.

Box 2
Regional Ranking of Cat Species Vulnerability

Sub-Saharan Africa
1. Black-footed cat
1. African golden cat
2. Cheetah (A)
2. Lion (A)
3. Serval
4. Leopard (A)
4. Caracal
5. African wildcat

North Africa and Southwest Asia
1. Cheetah (A)
1. Asiatic lion
2. Serval (A)
3. Leopard (A)
4. Sand cat
5a. Caracal (A)
5a. Jungle cat
5b. Wildcat

The Americas
1. Kodkod
1. Andean mountain cat
2. Jaguar (A)
2. Oncilla
3. Margay
3. Canada lynx
3. Geoffroy's cat
4. Puma (A)
4. Bobcat
4. Pampas cat
5. Jaguarundi

Tropical Asia
1. Tiger (A)
1. Bornean bay cat
2. Clouded leopard (A)
2. Asiatic golden cat
2. Flat-headed cat
2. Rusty-spotted cat
2. Fishing cat
2. Marbled cat
3. Leopard (A)
4. Jungle cat
5. Leopard cat

Eurasia
Asia sub-region
1. Snow leopard (A)
1. Chinese mountain cat
2. Asiatic wildcat
2. Manul
3. Eurasian lynx

Europe sub-region
1. Iberian lynx
2. Eurasian lynx
3. Eurasian wildcat

Note: Iriomote cat not ranked but high priority (see page xiv).
See pages 2-6 for explanation of vulnerability ranking system.

How fragmented are cat species populations?
Many cat species have been extirpated from large parts of their ranges, but this has rarely been mapped. Population fragmentation can result in small, isolated populations, which are particularly vulnerable to extinction. Mapping the detailed distribution of cat populations will greatly aid in fixing priorities for the conservation effort, and a number of Action Plan projects have been put forward to start this process (Projects 3, 4, 19, 21, 25, 26, 28, 39, 41, 42, 49, 53, 59, 62, 65, 72, 73, 80, 90, 91, 92, 97, 99, and 104).

How can cats be counted effectively?
Because cats are mainly nocturnal and secretive, they are difficult to census. But it is impossible to assess the status of a species in a given area without reliable indexes of numbers and population trends. This is particularly important for the tiger, which is being heavily poached for bones and other parts. Two Action Plan projects (numbers 7 and 50) are designed to develop and promote appropriate census measures. One of them focuses on improving the counting technique used in India, which has a long history of tiger censuses and is home to most of the world's tigers. The improved techniques will be applicable in the census of other big cats.

How can the viability of cat populations be ensured?
Studies in conservation biology show that small, isolated populations are highly vulnerable to decline and extinction. Because cats occur at relatively low densities, most protected areas conserve only small populations. Are these populations too small to be viable? Project 8 aims to apply the MVP concept to cat species, particularly the larger cats, in the light of what is known of their biology and ecology. This information will then be used to analyze the viability of sub-populations throughout the range of a species. Other aspects of MVP conservation are covered, including the extent to which habitat corridors can enhance the persistence of a population by allowing the movement of individuals between populations (Project 50); the role of disease in small populations (Projects 11 and 27); limiting factors of populations (Projects 36, 46, and 55); and the ecology of isolated populations, particularly in terms of the impact of predation on numbers of prey (Project 29).

How can the conservation of full intraspecific diversity be ensured?
There is general agreement that most classically described cat subspecies are not valid, but little progress has been made in re-defining subspecies using modern techniques, including genetic analysis. The Action Plan identifies taxa for which both field conservation efforts, as well as genetic studies, are of highest priority (Projects 10, 36, 44, 46, 47, 56, 67, 69, 70, 78, 79, 89, 95, 100, and 105). In addition, it is recommended that field biologists increase their efforts to collect biological samples to help in evaluating subspeciation (Project 9), and that zoos continue their efforts to identify subspecies and conserve viable populations of key taxa (Project 15).

How can illegal trade in cat products be controlled effectively?
Commercial poaching and illegal trade are serious threats to some species. To minimize them, a great deal of information is required about the consumer market for cat products. There is a need to know about the size of the market, sales volume, trade channels and patterns, key players in the market, consumer motivation, and law enforcement measures and their effectiveness. This is most urgent for the tiger: the consumer market for tiger bone medicines has scarcely been investigated (Project 12).

How can the sustainability of hunting for cats be ensured?
Economic value is an important incentive for cat conservation, and some of the most significant values are derived from hunting for the fur trade and for sport. Projects are proposed to further develop management techniques to ensure that hunting pressure does not lead to major declines in numbers and that yields are sustainable (Projects 13, 33, and 98).

How can zoos contribute most effectively to cat conservation?
In terms of captive cat populations, experience in the genetic management of small populations, and the ability to promote cat conservation, zoos have resources which are becoming increasingly appreciated by the conservation community. Expertise in small population biology is called for in Project 8. In addition, as zoos become involved with conservation of wild populations, a zoo-sponsored fund for field conservation is proposed (Project 14).

How well does cat reintroduction work, and for which taxa is it a priority?
Reintroduction of captive-bred cats is often seen as a means of maintaining wild populations. However, re-introduction is a complicated matter and is not practical if the factors which led to the decline or extinction in the first place have not been alleviated. The establishment of a population can be difficult when habitat is fragmented and used by humans. Projects 16, 17, 84, and 85 monitor the long-term progress of reintroduction attempts. In general, reintroduction is not of high priority for cats, because none have become extinct in the wild, and efforts should first be focused on ensuring that they do not. However, the Asiatic lion is in a grave situation because it survives only as a single, highly vulnerable wild population in India's Gir Forest. As insurance against sudden, catastrophic extinction, a second population urgently needs to be established. Possible sites are being surveyed and assessed in India (Project 35).

Part III: Action Plan
Members of the Cat Specialist Group are involved in studies and conservation of cats in all the continents. They have provided information about their current projects, and proposed others that they consider priorities for conservation in the 1990s. Other projects have arisen from the research conducted to produce this document. Part III provides summaries of 105 projects. Some already have financial support, but most require funds if they are to be implemented. The Cat Specialist Group will actively seek funding for these priority projects, and hopes for sympathetic consideration by major institutions, as well as private donors.

Taxonomy of the Felidae

In practice, conservation of cats in the wild has to be based on populations rather than taxonomy, but taxonomy is an aid to prioritizing allocation of conservation resources between different populations. It is thus essential that classification schemes accurately capture felid diversity, in terms of not only morphology, but also genetics, and, if possible, ethology. The history of cat species classification, which has seen extremes in both "splitting" and "lumping," is reviewed below by Lars Werdelin in a paper written especially for this volume.

Wild Cats follows the taxonomy set out in the latest edition of *Mammal Species of the World* (Wozencraft 1993). Wozencraft has explained that his taxonomy is not a piece of primary research, but a compilation of recent literature. He evaluated what others had done, based on primary literature, discarding statements unsupported by data (C. Wozencraft *in litt.* 1993). His classification is used here for practical reasons, without prejudice, as it has been adopted by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and the World Conservation Monitoring Centre (WCMC).

Some of the new designations are controversial and will surely be the subject of future debate. One example is the Iriomote cat, which was originally described as a monotypic genus *Mayailurus iriomotensis* (Imaizumi 1967), but was later placed close to the leopard cat within the genus *Prionailurus* (Hemmer 1978a, Leyhausen 1979, Corbett and Hill 1993): it is now relegated to a subspecies of the leopard cat by Wozencraft (1993). If the Iriomote cat is considered a full species, it is the most endangered cat in the world, with a population of only 100 animals on the small Japanese island of Iriomote. If it is considered a subspecies, it becomes one of several island populations of the most common cat in Tropical Asia. Nevertheless, because of its distinctive characteristics, which led to the uncertainty in classification, the Iriomote cat merits special attention.

Modern taxonomic frameworks have lumped most of the smaller cat species into the genus *Felis*—29 according to the previous edition of *Mammal Species of the World* (Nowak and Paradiso 1983). Wozencraft (1993), however, broadly promotes the subgenera of the old genus *Felis* to full generic status, a step which better reflects the substantial variation among so many species. As Pocock (1951) noted in his Catalogue of the Genus *Felis*: "[The old genus] *Felis* is a heterogeneous, unwieldy assemblage, ranging practically all over the world, apart from Madagascar, some small islands and the Australian Region. Considering its wide distribution and exceedingly varied habitats, it would be strange if the family had not become differentiated into groups of generic status."

Under the new taxonomy, a number of former *Felis* species are now placed in monotypic genera: the caracal, jaguarundi, serval, Andean mountain cat, Pallas's cat, African golden cat, puma, and marbled cat. The three lynxes—Eurasian (*lynx*), Canada (*canadensis*), and Iberian (*pardinus*)—often labelled conspecific, have full species status within the genus *Lynx*. The strongly-patterned spotted South American cats—ocelot (*pardalis*), oncilla (*tigrinus*), and margay (*wiedi*)—have been placed in the genus *Leopardus*, while the lightly spotted cats of the southern region—pampas cat (*colocolo*), Geoffroy's cat (*geoffroyi*), and the kodkod (*guigna*)—are grouped in the genus *Oncifelis*. The Asiatic golden cat (*temmincki*) and the Bornean bay cat (*badia*) are placed together in the genus *Catopuma*. The snow leopard is separated from the genus *Panthera* and given full generic status as *Uncia uncia*.

With regard to subspecies, there is considerable debate on definition, and even whether the traditional taxonomic concept is valid in the light of contemporary knowledge of population biology and genetics. It is generally agreed that too many subspecies of cats have been described in the past on the basis of very slim evidence. However, there is some uncertainty as to how to proceed with redefinition, and the task is large—the Felid Taxon Action Group of the American Zoo and Aquarium Association (formerly the AAZPA), which is concerned mainly with appropriate representation of wild diversity through captive breeding, has recommended the re-evaluation of 235 out of 259 subspecies recognized by the group (Wildt *et al.* 1992a).

Molecular analysis is potentially an important tool for this exercise. The leopard, for example, shows great variation in coat pattern and size, but recent molecular studies have led to the proposal that all African leopards—nearly 30 have been described, living in habitats which range from desert to rain forest—should be considered one subspecies *Panthera pardus pardus* (Miththapala 1992). However, can such findings be reconciled with data gathered by classical anatomical measurements and descriptions, and with what new knowledge has been gained through field studies of behavior and ecology in different environments? In Part II Chapter 3, where the question of subspecies is discussed in more detail, Stephen O'Brien puts forward a useful definition, outlines the sort of evidence of differentiation that molecular biologists should look for, and stresses the need for cooperative work between the different scientific disclipines.

Given the difficulty of defining subspecies and the lack of comprehensive evaluation at this level of the family Felidae, this Action Plan refers only to those subspecies

Box 1
Classification of the Felidae
by W. Christopher Wozencraft (1993)

Family Felidae G. Fischer, 1817

Subfamily Acinonychinae Pocock, 1917

Acinonyx Brookes, 1828	
jubatus Schreber, 1776	Cheetah

Subfamily Felinae Fischer, 1817

Caracal	
caracal (Schreber, 1776)	Caracal
Catopuma Severtzov, 1858	
badia (Gray, 1874)	Bornean bay cat
temmincki [1] (Vigors and Horsfield, 1827)	Asiatic golden cat
Felis	
bieti Milne-Edwards, 1892	Chinese mountain (desert) cat
chaus Schreber, 1777	Jungle cat
margarita Loche, 1858	Sand cat
nigripes Burchell, 1824	Black-footed cat
silvestris Schreber, 1775	Wildcat of Africa and Eurasia
Herpailurus	
yaguarondi Lacépéde, 1809	Jaguarundi
Leopardus Gray, 1842	
pardalis (Linnaeus, 1758)	Ocelot
tigrinus (Schreber, 1775)	Oncilla, Little tiger cat
wiedi (Schinz, 1821)	Margay
Leptailurus Severtzov, 1858	
serval (Schreber, 1776)	Serval
Lynx Kerr, 1792	
canadensis Kerr, 1792	Canada lynx
lynx (Linnaeus, 1758)	Eurasian lynx
pardinus (Temminck, 1824)	Iberian lynx
rufus (Schreber, 1776)	Bobcat
Oncifelis Severtzov, 1858	
colocolo (Molina, 1782)	Pampas cat
geoffroyi (d'Orbigny and Gervais, 1844)	Geoffroy's cat
guigna (Molina, 1782)	Kodkod
Oreailurus Cabrera, 1940	
jacobitus (Cornalia, 1865)	Andean mountain cat
Otocolobus Brandt, 1842	
manul (Pallas, 1776)	Pallas's cat
Prionailurus Severtzov, 1858	
bengalensis (Kerr, 1792)	Leopard cat
planiceps (Vigors and Horsfield, 1827)	Flat-headed cat
rubiginosus (I. Geoffroy Saint-Hilaire, 1831)	Rusty-spotted cat
viverrinus (Bennett, 1833)	Fishing cat

Continued on next page

Profelis Severtzov 1858.	
aurata (Temminck, 1827)	African golden cat
Puma Jardine, 1834.	
concolor (Linnaeus 1771)	Puma, Cougar, or Mountain lion
Subfamily Pantherinae Pocock 1917	
Neofelis Gray, 1867	
nebulosa (Griffith, 1821)	Clouded leopard
Panthera Oken, 1816.	
leo (Linnaeus, 1758)	Lion
onca (Linnaeus, 1758)	Jaguar
pardus (Linnaeus, 1758)	Leopard
tigris (Linnaeus, 1758)	Tiger
Pardofelis Severtzov, 1858	
marmorata Martin, 1837	Marbled cat
Uncia Gray 1854	
uncia (Schreber, 1758)	Snow leopard

Wozencraft, W.C. 1993. Order Carnivora. Pp. 286-346 in D.E. Wilson and D.M. Reeder, eds. *Mammal species of the world: a taxonomic and geographic reference (Second edition).* Smithsonian Institution Press, Washington D.C. and London.

[1] *jacobita, wiedii,* and *temminckii* in Wozencraft (1993) amended to *jacobitus, wiedi,* and *temmincki* in accordance with the 1985 International Code of Zoological Nomenclature Article 31a mandating that patronymic species names follow the rules of Latin grammar.

Note: Brackets round the name of the authority indicate that the genus has been changed since first publication by that authority.

which have been relatively rigorously evaluated, and generally prioritizes conservation action at the species level. However, it is also recognized that preservation of a species includes its full diversity, and that at present it is intra-, rather than interspecific diversity, which is most threatened in the cat family. A list of classically described subspecies is included in Appendix 1, and much greater effort should be directed towards defining differentiation within cat species through more extensive collection and analysis of field samples. A protocol for the collection of field samples, a collaborative effort by a museum-based anatomist and a wildlife veterinarian, is contained in Appendix 2. There are a number of taxonomy-related priority projects in Part III.

Below, Lars Werdelin reviews historical efforts to classify cat species, and Stephen O'Brien discusses the usefulness of genetic analysis in clarifying felid evolutionary history.

The History of Felid Classification

by Lars Werdelin

Like most other groups of organisms, felids have been the subject of a number of revised classifications since Linnaeus (1758), in the 10th edition of his *Systema Naturae*, laid down the first foundations by naming the genus *Felis*. The following is an attempt to provide a brief history of these classification attempts, illustrating our growing understanding of the interrelationships of the living cats. In addition to the works discussed here, which are all mainly concerned with living felids, there have been many works that in a general way have tried to relate fossil and living felid taxa. However, most of these have not dealt specifically with the ancestors of living species, or where they have done so, have concerned themselves with only a limited set of taxa. Werdelin (1981) is an example of such a study. These have not been considered in this review.

The first author specifically to consider relationships between species within the family Felidae was Jardine (1834). He distinguished five genera, *Leo, Puma, Cynailurus, Lynchus,* and *Felis*. In the first of these he placed only the lion, then separated into two species. In the second he had the puma, the jaguarundi, and the pampas cat (one color phase). In *Cynailurus* he placed only the cheetah. In *Lynchus* he placed the Eurasian and Canada lynxes, as well as the bobcat, caracal, African golden cat, Geoffroy's cat, jungle cat and black-footed cat. In *Felis*, finally, he placed all other species known at that time: tiger, leopard, jaguar, snow leopard, ocelot, margay, oncilla, leopard cat, clouded leopard, serval, pampas cat (other color phase), and European, African, and Asian wild cats. He did not consider relationships within these genera.

Although quite different from our current conception of felid interrelationships, Jardine's classification nevertheless contains some themes which have run through the subject ever since. These include the recognition of a genus *Felis sensu stricto* (although broader than currently conceived); the recognition of *Lynx* as a distinct genus (also broader than currently conceived); the relationship between the caracal and the lynxes; and the relationship between the puma and the jaguarundi. The latter relationship, which is highly controversial, has been supported by many authors since, and it is interesting to find its roots at such an early stage of the game.

Jardine was a precursor and his classification a crude first attempt, although an interesting one. The modern age of felid classification begins with Severtzov (1857-1858). This author discussed the evolution of carnivores in general and felids in particular, with special emphasis on biogeography and its relationship to felid classification. In the process of so doing he erected a number of new genus-level names as subgenera. In total, his classification includes five genera and 27 subgenera. Severtzov's exposition is not easy to follow, perhaps because he had planned to follow this work by a more extensive monograph on the group, where he intended to publish the characteristics of his various groups. This work was apparently never published. Fortunately, Allen (1919b) published a clarification of Severtzov's concepts, considerably simplifying a review.

Severtzov's genera are as follows:

1. *Tigris*, which includes two subgenera, *Leo* for the lion and *Tigris* for the tiger.
2. *Panthera*, with the subgenera *Jaguarius* for the jaguar, *Panthera* for the leopard, *Uncia* for the snow leopard and clouded leopard, and *Puma* for the puma.
3. *Cynailurus*, with the single species *Cynailurus jubatus*, the cheetah.
4. *Lynchus*, with two subgenera: *Lynchus* for the Eurasian lynx, Canada lynx, and bobcat, and *Urolynchus* for the caracal.
5. *Felis*, which contains no less than 19 subgenera, mostly monotypic.
   - *Oncoides:* ocelot, margay, and oncilla;
   - *Pardofelis:* marbled cat;
   - *Catopuma:* Temminck's golden cat;
   - *Herpailurus:* jaguarundi;
   - *Leptailurus:* serval;
   - *Chrysailurus:* for one variety of the African golden cat;
   - *Catolynx:* domestic cat (in which he presumably included the European wildcat), the African wildcat, and the jungle cat;
   - *Otocolobus:* manul;
   - *Lynchailurus:* pampas cat;
   - *Oncifelis:* Geoffroy's cat;
   - *Noctifelis:* kodkod;
   - *Profelis:* another variety of the African golden cat
   - *Dendrailurus*, which is based on an unidentifiable species;
   - *Felis*, which is preoccupied by Linnaeus' *Felis* for the domestic cat;
   - *Prionailurus:* leopard cat;
   - *Zibethailurus:* fishing cat;
   - *Ictailurus:* flat-headed cat;
   - *Otailurus*, for a species from Timor that I am currently unable to identify.

This enormous proliferation of generic-level names clearly does nothing to increase our knowledge of the interrelationships of the various species. However, it should be noted that most of the names used by Severtzov, whether newly coined by him or adopted from earlier authors, are still in use for various groupings of felid taxa. In Severtzov's classification we see the seeds of a modern concept of Panthera in his genera *Panthera* and *Tigris*. His concept of *Lynx* is also very close to the current one. His *Oncoides* represents the beginnings of the currently recognized *Leopardus* for the small spotted felines of South America. Other than this, Severtzov's contribution is mainly at the nomenclatural level, albeit a very modern one.

While Severtzov was publishing his work, Gray (1867) was completing his studies of felid classification. Gray was apparently unaware of Severtzov's work, and therefore there is extensive overlap between them, as well as a number of synonymous taxon names. In Gray's classification, the pantherines are separated into four genera: *Uncia* for the snow leopard; *Leo* for the lion; *Tigris* for the tiger; and *Leopardus* for the leopard, jaguar, African golden cat, and puma. This is one of the few notions that the golden cats are related to the pantherine big cats. The genus *Neofelis* includes the clouded leopard, whereas the genus *Pardalina* includes an unidentified species, *P. himalayensis*, possibly an ocelot. The genus *Catolynx* in Gray's conception includes only the marbled cat. This genus is therefore synonymous with Severtzov's *Pardofelis*, but is itself a junior homonym of *Catolynx* of Severtzov, which is a junior synonym of *Felis sensu stricto* (they are based on the same type species). This chain reaction is a good illustration of why the parallel work of Severtzov and Gray has led to over 100 years of nomenclatural confusion in felids. No wonder many workers take refuge in calling everything *Felis*.

Gray's genus *Viverriceps* includes the fishing cat, flat-headed cat, rusty-spotted cat, and one variety of leopard cat; his genus *Pajeros* includes only the pampas cat. In the genus *Felis* Gray places the ocelot, margay, oncilla, Geoffroy's cat, jaguarundi, serval, Asiatic golden cat, manul and the European, African, and Asian wildcats, along with the domestic cat. In his genus *Chaus* he places the jungle cat, while in *Lyncus* he has the Eurasian, Canadian, and Iberian lynxes, and the bobcat. His genus *Caracal* accounts for the caracal, while in *Gueparda*, finally, he places the cheetah.

As noted, Gray's work introduced some confusion in the nomenclature, but he is more specific regarding interrelationships than Severtzov, for whom most species belonged in their own genera. Gray's genus *Viverriceps*, for example, is a specific statement of relationships between four species of southeast Asian felid. His concept of *Lynx* is the same as that currently in use. On the other hand, his *Felis* includes both species currently placed in that genus and a number of species currently believed to be only distantly related to *Felis sensu stricto*.

Some semblance of order was created out of the nomenclatural confusion by Pocock (1917), who has perhaps done more than any other biologist to further the cause of felid classification and systematics. He separated the Felidae into three subfamilies: Felinae for the small cats, Pantherinae for the large (roaring) cats, and Acinonychinae for the cheetah. This classification was based on the structure of the hyoid (ossified in Felinae and Acinonychinae, imperfectly ossified in Pantherinae) and the digits (cutaneous lobe protecting retracted claw in Felinae and Pantherinae, no cutaneous lobe in Acinonychinae). This is a scheme which, with few exceptions, has been followed until very recently.

Within the Pantherinae, Pocock distinguished two genera: *Panthera* for the lion, tiger, leopard, and jaguar; and *Uncia* for the snow leopard. Within the Felinae, he tried to arrange Severtzov's and Gray's genera in an orderly manner. Pocock's *Felis* includes, in his terms, "three categories": medium-sized cats from Europe, southwest Asia, and Africa (these are not specified, but presumably include the European, Asian, and African wildcats); larger species ranging from Burma, through India, and into parts of central Asia (this group he specifically states is identical with Gray's genus *Chaus*, i.e., the jungle cat); and the very small South African species *F. nigripes*, the black-footed cat. As Pocock is no more explicit about the species of *Felis* than this, it is not clear where he placed the sand cat, Chinese mountain cat, etc. relative to these three groups.

Within *Lynx* Pocock also distinguishes three groups: one for the Eurasian, Canada, and Iberian lynxes; one for the bobcat; and one for the caracal. He places the manul in the genus *Trichaelurus*, the puma in the genus *Puma*, and the serval in the genus *Leptailurus*. In *Prionailurus* he includes both the leopard cat and the rusty-spotted cat, while in *Pardofelis* he places the marbled cat and the Bornean bay cat. The genus *Profelis* includes both the African and Asiatic golden cat, the first association of these two species.

His genus *Zibethailurus* includes the fishing cat, while *Ictailurus* includes the flat-headed cat. *Neofelis* includes the clouded leopard, while *Leopardus* includes only the ocelot and margay. The other small South American cats (excepting the pampas cat, which Pocock identifies with that species made the type species of *Dendrailurus* by Severtzov) are included by Pocock in *Herpailurus*, which accordingly accommodates the jaguarundi, kodkod, Geoffroy's cat, and oncilla.

In summary, Pocock's genera are to a great extent congruent with those recognized at present. His *Panthera*, *Felis*, and *Lynx* (almost) are those currently in use, as are many of his smaller groups. However, Pocock's aim was strictly a classification, and he did not go beyond this scheme to look at the interrelationships of the groups he produced. This somehow led to the impression that there were no such interrelationships to be obtained from the data, and this, coupled with the massive influence of Pocock's work, caused research on felid classification and systematics to grind to a halt for more than half a century.

During this hiatus there were no studies emphasizing felid classification. Some works, such as that of Weigel (1961), include evolutionary schemes for the Felidae that can be made into classifications, but this was not their main aim. Finally, Hemmer (1978a) produced a considered view of felid interrelationships. Hemmer also provides a phylogenetic tree, which none of the older workers did. Therefore, his scheme of relationships, and by extension his classification, is more explicit than those of Severtzov, Gray and Pocock (Fig. 1).

Hemmer considers the genus *Felis sensu stricto* to be monophyletic, incorporating the European, African, and Asian wildcats, which are considered closely related, and the black-footed cat, Chinese mountain cat, sand cat, and jungle cat. Related to these are also the manul, placed in the genus *Otocolobus*, and the lynxes, *Lynx*, the caracal, *Caracal*, and the serval, *Leptailurus*. The genus *Prionailurus* is extended in Hemmer's scheme to include

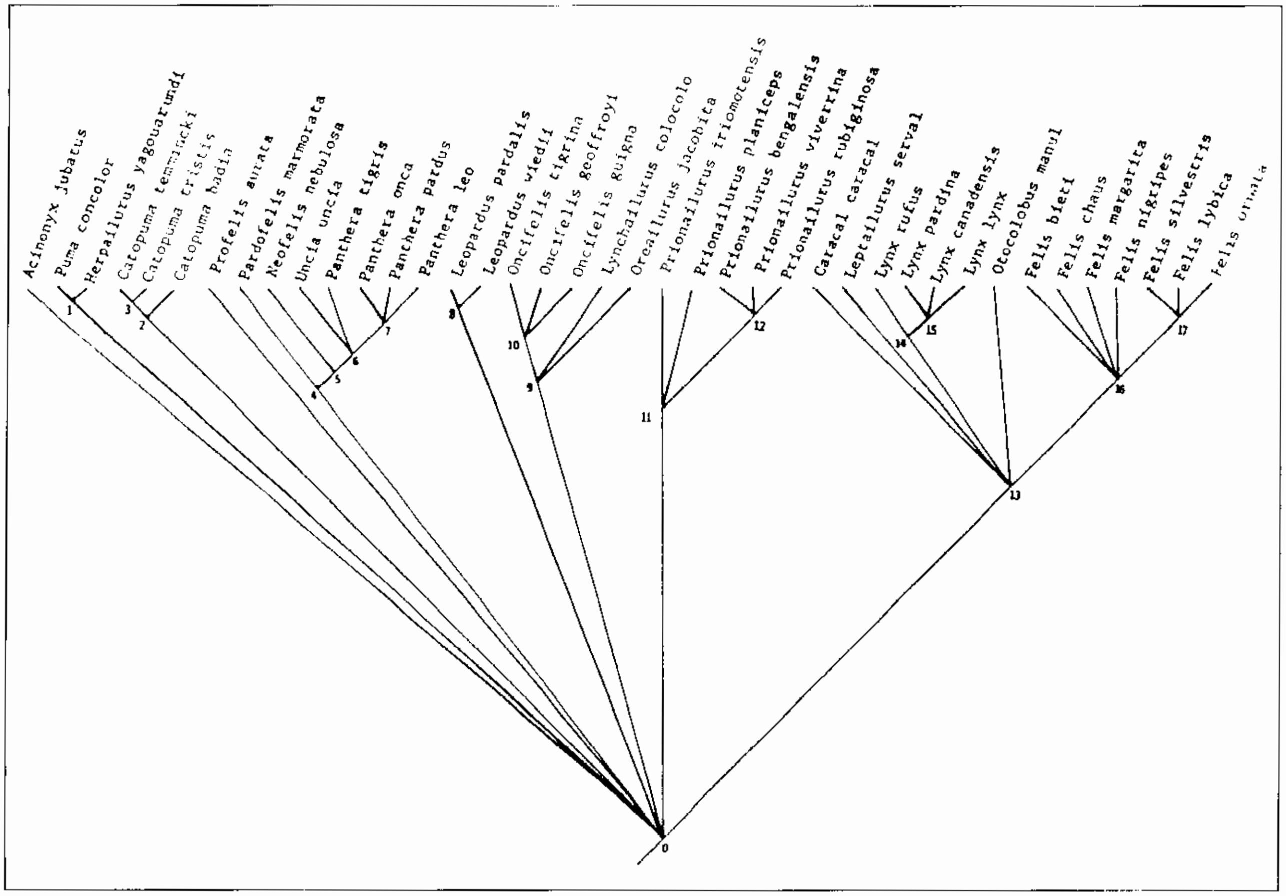

Figure 1. Branching diagram derived from the phylogenetic tree proposed by Hemmer (1978). Source: Salles (1992).

the Iriomote cat, flat-headed cat, leopard cat, rusty-spotted cat, and fishing cat, of which the last three are considered more closely related. The small South American forms are separated into *Leopardus* for the ocelot and margay, *Lynchailurus* for the pampas cat, *Oreailurus* for the Andean mountain cat, and *Oncifelis* for the oncilla, Geoffroy's cat, and kodkod.

Hemmer's *Panthera* includes the same four species as Pocock's, but he considers the tiger more distantly related than the other three, along with the snow leopard, *Uncia*. In the large cat clade he also has the clouded leopard, *Neofelis*, the marbled cat, *Pardofelis*, and the African golden cat, *Profelis*. In *Catopuma* Hemmer united the Bornean bay cat and Asiatic golden cat. The cheetah is alone in *Acinonyx*, while he sees a close relationship between the puma, in *Puma*, and the jaguarundi, in *Herpailurus*.

The next step in felid systematics and classification was essentially twofold. In 1985, Collier and O'Brien published the first molecular systematic study of the Felidae, with a number of innovative results (see next paper). My view of classification essentially follows theirs, with a threefold division into the small South American spotted cats (*Leopardus*), the *Felis sensu stricto* lineage (including the manul), and the pantherine lineage with *Lynx* as the sister group of *Panthera*.

At the same time as Collier and O'Brien, Herrington (1986) prepared a systematic study and classification of felids (Fig. 2), with partially congruent results. She also has *Panthera* and *Lynx* closely related, although separated by the marbled cat and clouded leopard. Herrington further recognizes *Leopardus* in more or less the same way as Collier and O'Brien, although she considers *Profelis*, including the golden cats and the Bornean bay cat, closely related to the South American group. Herrington also recognizes *Felis sensu stricto*, but has the caracal and rusty-spotted cat as close relatives of this genus. She sees the cheetah, jaguarundi, manul, and puma as closely related, and identifies a genus *Prionailurus* including the fishing cat, leopard cat, flat-headed cat, and Iriomote cat.

It is noteworthy that the three assessments by Hemmer, Collier and O'Brien, and Herrington all depart more or less strongly from the threefold subfamilial division—the big cats, the small cats, and the cheetah—espoused by Pocock. The most recent studies depart strongly from this scheme

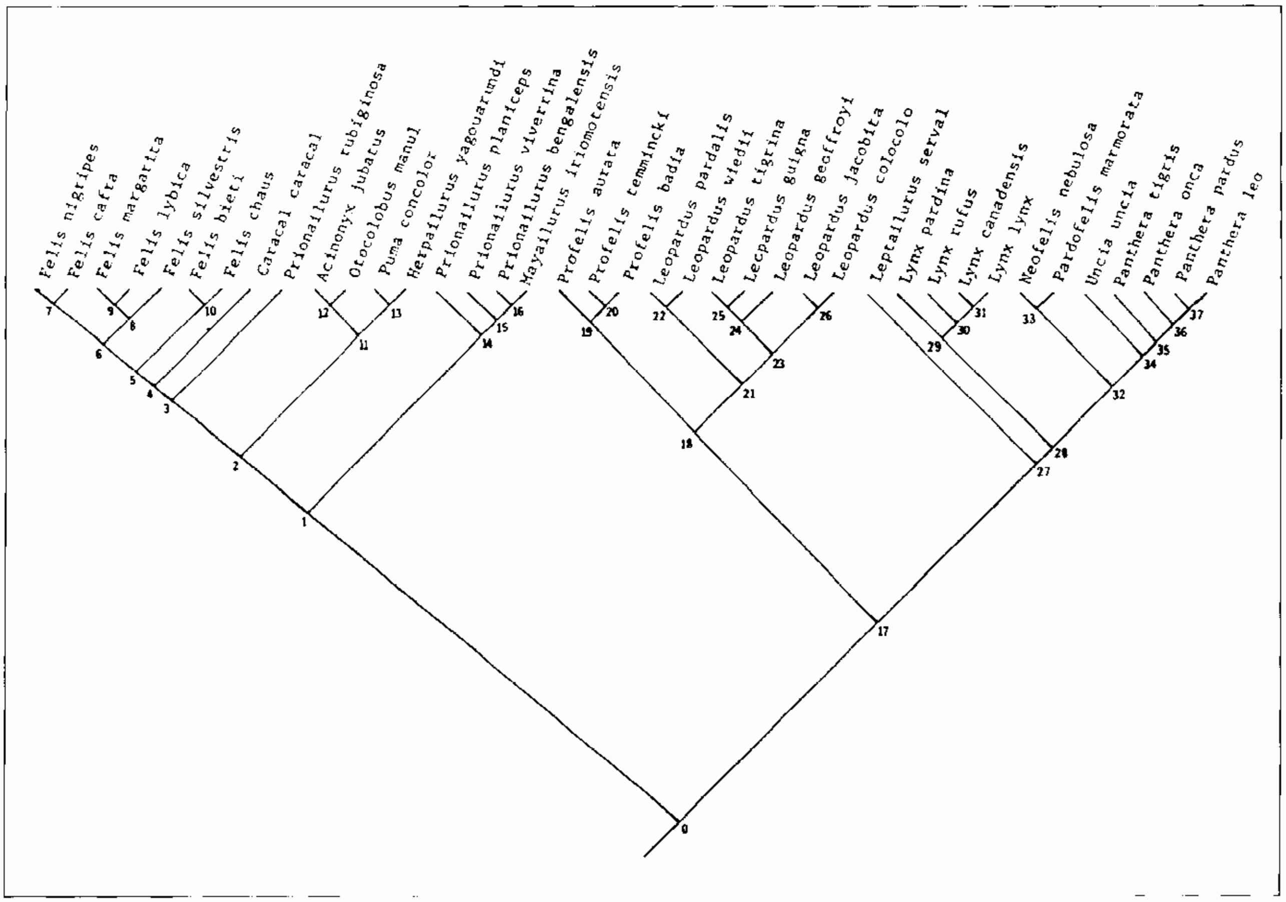

Figure 2. Branching diagram redrawn from the cladogram for extant felids proposed by Herrington (1986). Source: Salles (1992).

by placing the cheetah well within the felid radiation, instead of as a separate lineage as was done by the earlier workers, including Hemmer.

Another recent work in the field of felid systematics and classification is that of Salles (1992). His study recognizes two well-resolved groups and a basal group of less well understood taxa (Fig. 3). One of the well-resolved groups includes the genus *Felis sensu stricto*, which in Salles' view includes the manul. This genus is related to *Lynx*, including the caracal. In this larger group we also have the marbled cat, Bornean bay cat, and Asiatic golden cat.

Salles' second large group is the pantherine group, which beside *Panthera* also includes the clouded leopard, cheetah, snow leopard, puma, and jaguarundi. The rest of Salles' relationships are basically unresolved, but we may note the suggestion that the flat-headed cat and fishing cat are closely related and are the basal felid group.

Wozencraft's (1993) classification, used in this volume, is the most recent evaluation of the felid family. He recognizes three suprageneric groups: the Acinonychinae for the cheetah, the Felinae for the small cats, and the Pantherinae for the large cats. He includes *Neofelis* and *Pardofelis* in the Pantherinae along with *Panthera* and *Uncia*, which reflects the opinion of some workers (i.e., Hemmer) that the small marbled cat is actually closely related to the large cat group.

This survey represents a sample of the work on felid classification and systematics undertaken during the past >150 years. It is by no means complete, not taking into account work by authors such as Matschie, Satunin, Groves, Kratochvil, and others. However, a complete review would occupy far too much space, and this brief overview is more or less representative of the diversity of views on the subject.

What can we learn from this history? I feel that there are two things that need to be pointed out. The first is that the divergence of opinion regarding felid systematics expressed in even the most recent works suggests that considerable further work is required before a stable consensus can be reached. Such a consensus must involve both morphological and molecular work. The second important point to be learned is that nearly all first-hand studies of felid systematics and classification have separated felids into a number of different genera, just as has been done in other families of carnivores. The view of the Felidae as including only the genera *Felis*, *Panthera*, and *Acinonyx* is only seen in the non-specialist literature and should be laid to rest once and for all.

Molecular Genetics and Phylogenetics of the Felidae

by Stephen J. O'Brien

A fundamental component of conservation strategies for threatened species is the systematic classification of species and significantly differentiated populations below the species level (subspecies). Uncertainty over the units of conservation leads not only to confusion in establishing management plans, but risks critical mistakes in establishing priorities in cases where taxonomy is based on inadequate descriptions with only historic precedence to affirm their precision. In the past decade conservation efforts for several species have been both advanced and hindered by our knowledge (or lack of knowledge) of their taxonomic status (Daugherty *et al.* 1990, May 1990, O'Brien and Mayr 1991). Taxonomic questions involving species, subspecies, hybrids, and inbreeding effects will become increasingly important as wild populations become smaller and increasingly isolated and as captive populations are managed more intensively.

The taxonomy of the cat species is an area of much disagreement, as previously discussed by Lars Werdelin. For

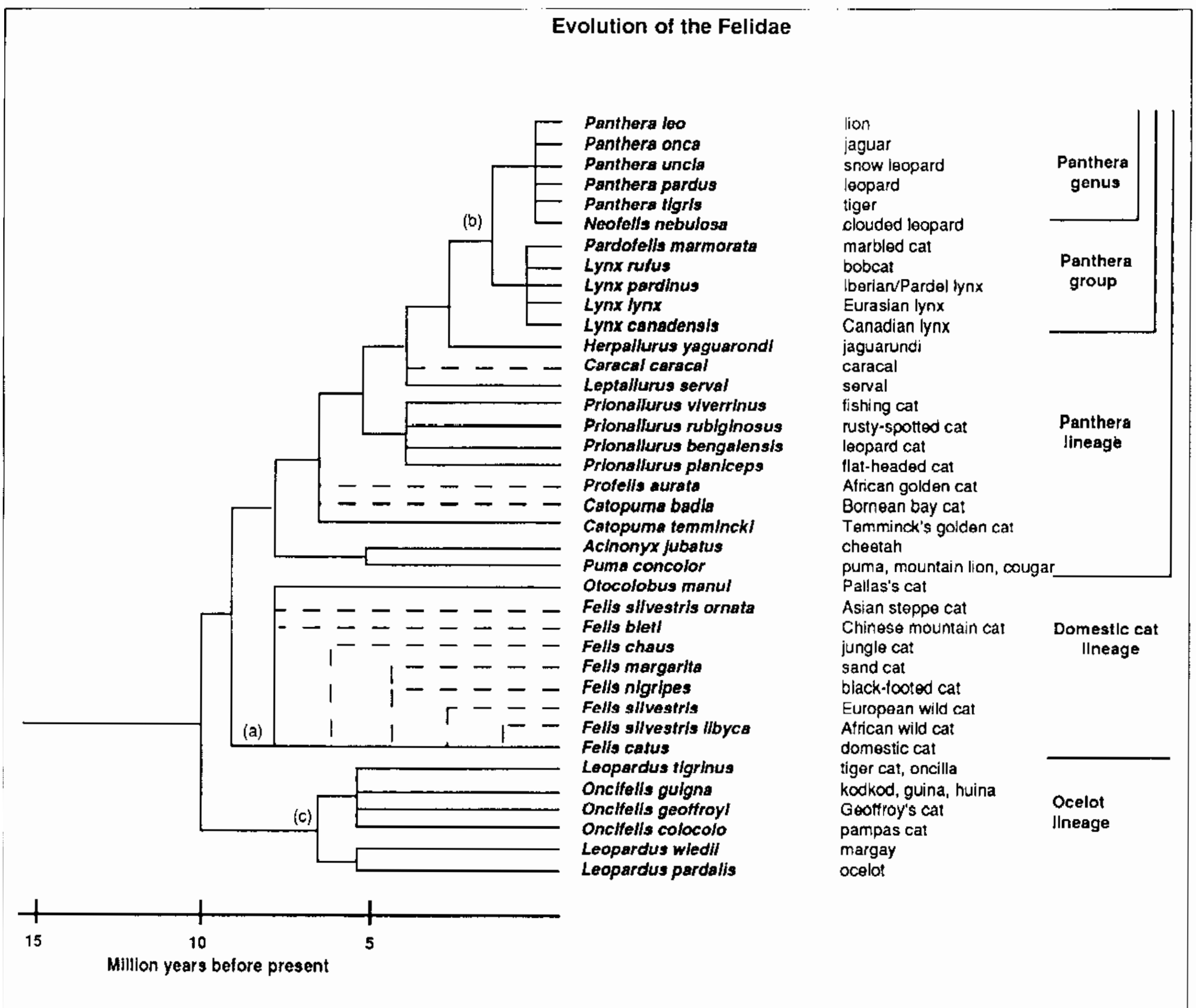

Figure 3. Phylogenetic relationship of felid species based on a consensus of molecular, karyologic, and morphological characters. (S.J. O'Brien).

example, the most recent edition of *Walker's Mammals of the World* (Nowak and Paradiso 1991) lists four different taxonomic schemes (after Leyhausen, Hemmer, Ewer, and others), which lump cat species into as few as four genera or split them into as many as 19.

Paleontologists tell us that the two carnivore families, Felidae and Canidae, diverged from a common ancestor about 50 million years ago because the "missing link" fossils that share characteristics of the two families are approximately this age. By measuring the quantitative differences that occur in genes and DNA sequences of cats and dogs, we have developed a good quantitative estimate of the amount of mutational change that occurred in these groups over the past 40 million years. This calibration, termed the "molecular clock," is not the perfect evolutionary timepiece, but it has helped resolve a number of controversies in evolutionary studies.

Several molecular metrics have been applied to estimate relationships between cat species, using blood and skin cell cultures as the biological materials. The Felidae is a relatively difficult group to analyze in this way, as there are many species which have split from each other relatively recently. Five different methods have been applied to samples from living cat species. Three of these, allozyme genetic distance (O'Brien *et al.* 1987d), 2DE genetic distance (Goldman and O'Brien 1993), and albumin immunological distance (Collier and O'Brien 1985), measure differences in protein (gene product) sequences. Two methods, DNA-DNA hybridization (Wayne *et al.* 1989) and DNA sequence analysis, compare the specific DNA sequence code of different cat species.

The results are neither perfect nor complete, but they have converged on several conclusions and on a "best" phylogenetic tree based on concordance of the various molecular tests. The molecules, when calibrated and interpreted along with certain fossil remains, describe a scenario that is summarized in Fig. 3. The major conclusion derived from the molecular topology was the resolution of felid evolution into three major lineages. The earliest branch occurred approximately 12 million years ago and led to the small South American cats (ocelot, margay, oncilla, Geoffroy's cat, and others). The second branching occurred about 8 to 10 million years ago and included the close relatives of the domestic cat (wildcats, jungle cat, sand cat, black-footed cat) and the manul. About 4-6 million years ago a gradual divergence of mid-sized and large cats began: the most recent (1.8-3.8 million years ago) produced a split of the lynxes and the big cats.

One dramatic surprise revealed by the molecular method was the placement of the morphologically specialized cheetah in the midst of the mid-sized cat radiation. Earlier taxonomists had largely agreed that the cheetah's adaptive specializations for high-speed sprinting merited separate generic status and likely indicated an early divergence from the felid evolutionary tree. The molecules did not agree. In addition, recent DNA sequence data on mitochondrial DNA genes suggest that the cheetah's closest living relative is the American puma (Janczewski 1993).

Re-examination of other non-molecular characters of the Felidae in the context of the molecular trees has not only reinforced certain patterns, but has also shed light on the evolutionary processes that occurred in this group. For example, the chromosomes of all the major cat groups (that is, big cats, domestic cat relatives, and South American small cats) look identical within the clusters, but distinct from other groups. Further, many of the anatomical similarities between cat species that have confounded the experts are now beginning to make more sense. We certainly do not have all the answers yet, but the recent advances in our understanding of molecular evolution of cat genomes offers the prospect that resolution of these thorny taxonomic issues may now be within our reach. Properly interpreted, a consensus molecular, morphological, and ethological classification scheme would provide a framework for conservation programs.

Part I
Species Accounts

Introduction

The cats are grouped according to the five geopolitical regions in which they occur: (1) Sub-Saharan Africa; (2) North Africa and Southwest Asia; (3) Tropical Asia; (4) Eurasia; and (5) the Americas. There are no cats (other than domestic) in Australasia and Oceania.

Some cats occur in more than one region. Where there is sufficient information, an account has been written for each region in which a species occurs (cheetah, caracal, wildcat, lion, and leopard); otherwise, a single species account is included under the region with which the species is most strongly associated.

Each regional chapter opens with a table which ranks the vulnerability of the species occurring in the region. Species Accounts are presented in that order. This introduction explains the structure of the Species Accounts and the ranking of species vulnerability.

Structure of the Species Accounts

Other Names

Species names are given in local languages within their range, as well as in the three international languages: French, German, and Spanish. Readers are invited to forward other local names, or correct any given in the Species Accounts, in order to build up the database.

Description and Behavior

Because photographs are provided, physical descriptions are kept to a minimum, but include general appearance, distinguishing features, and adult weight. Readers should bear in mind that body weight can be substantially influenced if the cat has a full stomach: for example, Wilson (1968) reported that the stomach contents of a 43 kg female leopard weighed 6.6 kg, or 18% of her body weight. It was not generally possible to distinguish from the literature whether reported weights accounted for stomach contents. Characteristic aspects of the species' behavior and ecology, including diet, are discussed. Common names of prey species are used, and their scientific names listed in Appendix 3.

Biology

This section includes basic biological data, which are generally sparse, and typically derived from captive animals (labelled C in the Species Accounts). Information obtained from studies of cats in the wild (labelled W) is often known for only a small portion of the total range. Populations elsewhere may differ significantly (e.g. seasonality of reproduction, longevity, mortality rates).

Habitat and Distribution

Habitat preference and association is discussed, and distribution is illustrated in range maps.

Population Status

Vulnerability ranking (see following section for explanation) and status according to the 1994 IUCN Red List of Threatened Animals (Groombridge 1993: see Box 2) are given, and current information on the status of wild populations is presented, including data on density and home range size, where available.

Protection Status

International protection: all cats were listed on either Appendix I or II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) by 1977, so that international commerce in cats (dead or alive), their pelts, and other products has been either prohibited or regulated since that time (see the Trade chapter in Part II). Dates are given for cases where CITES listings were subsequently changed. National legislation: categorizes the type of legal protection cats receive in their range states.

Occurrence in Protected Areas

Protected areas where the species is known or suspected to occur are shown on the distribution maps. Information on occurrence in protected areas was gathered from a wide variety of sources, including IUCN protected area directories (IUCN 1982, 1987a, 1990a, Green 1993 -with reported occurrence independently confirmed where possible), the voluminous files of the Protected Areas Data Unit of the World Conservation Monitoring Centre in Cambridge, databases maintained by national governments and institutions, the literature and, most importantly, data provided by correspondents. Generally, priority was given to larger reserves, but the data are patchy and the maps reflect this. For some species, it was not possible to display all protected areas in which presence is known; for others, occurrence is insufficiently known and only a few protected areas are indicated. For a very few species, the amount of habitat needed to support minimum viable populations has been calculated, and protected areas of the requisite size are marked with a square on the maps.

Protected areas are named according to the management categories developed by the IUCN Commission on National Parks and Protected Areas, which are used by the United Nations in their List of National Parks and Protected Areas (IUCN 1990b), and by the Protected Areas Data Unit of the World Conservation Monitoring Centre, which maintains an extensive international database. The categories standardize the type of legal protection and management extended to an area.

I. Scientific Reserve/Strict Nature Reserve
II. National Park
III. Natural Monument/Natural Landmark
IV. Managed Nature Reserve/Wildlife Sanctuary
V. Protected Landscape (recreational activities predominate)
VI. Resource Reserve
VII. Natural Biotic Area/Anthropological Reserve
VIII. Multiple-Use Management Area/Managed Resource Area
IX. Biosphere Reserve

If a category has not been assigned, the full name of the reserve is given. Protected areas which have been listed as Biosphere Reserves under the UNESCO Man and the Biosphere program are designated *. Protected areas which have been accepted as World Heritage Sites under the Convention Concerning the Protection of the World Cultural and Natural Heritage (1975) are designated **. Protected areas which qualify as both are denoted #.

Principal Threats

A brief overview of the major threats, focusing on those that particularly affect that species. Threats affecting cats in general are discussed at length in Part II, rather than in the Species Accounts.

Action Planning

A link to relevant priority projects in Part III.

Categorization of Species Vulnerability

A system to rank species according to their vulnerability to extinction was developed for this Action Plan. There are five categories of vulnerability, with "1" the highest. Species are ranked on a global scale (in relation to all other cat species) in Box 1, as well as a regional scale (in relation to other cat species occurring there). Regional rankings are summarized at the start of each regional chapter in Part I, and both global and regional species rankings are given in the Species Accounts under Population Status.

The ranking system was developed in order to provide an objective method for prioritizing species and populations for conservation. IUCN maintains a Red List of species of conservation concern, but the criteria for their categories of threat were not quantitative, and new criteria have been developed (IUCN Species Survival Commission 1995). Because many people are accustomed to the old system, and for purposes of comparison, the 1994 Red List rankings are also given in the Species Accounts. Definitions of the IUCN rankings are given in Box 2.

Most attempts to rank species vulnerability objectively, including the new IUCN threat criteria, involve estimates of population size and/or rate of decline. However, given the paucity of data on density and species presence or absence, it is not possible to derive reliable quantitative estimates of total numbers or rate of change in abundance for cats (see Part II, Chapter 3 for discussion of the difficulties of counting cats). The method used in this document to rank species vulnerability is based on other factors which influence population size and extinction risk: habitat association, geographic range area, and body size. Hunting pressure is also accounted for as an active threat with the potential to remove animals from otherwise viable portions of their range. For global comparison, each cat species was scored for these criteria as described below. For regional rankings, the criteria are the same but the scoring may differ (see the introductions to each regional chapter).

Criterion 1. Habitat Association

Species which are associated with a narrow spectrum of habitats are more vulnerable to extinction than species which are more broadly associated.

The occurrence of cat species in a standard set of global habitat types (Olson *et al.* 1983) was evaluated. The habitat classification is described in Part II, Chapter 1, and maps of the global distribution of these habitat types are included. The degree of species association with a particular habitat type was assigned as strong, significant, marginal, or

Box 1
Worksheet Summary for Global Cat Species Vulnerability Rankings

Species	Habitat Association St [Mar] (Tot) Score	Geog. Range (10^6 km^2)	Score	Body Size in kg	Score	Total Score
Category 1						
Iberian lynx, *L. pardinus*	N: 3 [3] (6) -1	R: 0.08	-2	M: 9.3	0	-3
Category 2						
Tiger (A), *P. tigris*	I: 6 [3] (9) 0	S: 1.99	-1	L: 136.0	-1	-2
Snow leopard (A), *U. uncia*	I: 1 [6] (7) 0	S: 2.39	-1	L: 37.5	-1	-2
Bornean bay cat, *C. badia*	N: 2 [0] (2) -1	R: 0.05	-2	S: 2.4	+1	-2
Chinese mtn. cat, *F. bieti*	N: 2 [3] (5) -1	R: 0.29	-2	S: 6.5	+1	-2
Black-footed cat, *F. nigripes*	N: 3 [0] (3) -1	R: 0.95	-2	S: 1.2	+1	-2
Kodkod, *O. guigna*	N: 2 [2] (4) -1	R: 0.16	-2	S: 2.2	+1	-2
Andean mtn cat, *O. jacobitus*	N: 2 [0] (2) -1	R: 0.62	-2	S: 4.0	+1	-2
Flat-headed cat, *P. planiceps*	N: 3 [0] (3) -1	R: 1.18	-2	S: 1.9	+1	-2
Fishing cat, *P. viverrinus*	N: 5 [1] (6) -1	S: 2.33	-1	M: 6.8	0	-2
African golden cat, *P. aurata*	N: 3 [2] (5) -1	S: 2.46	-1	M: 10.0	0	-2
Category 3						
Cheetah (A), *A. jubatus*	I: 4 [4] (8) 0	M: 7.35	0	L: 43.0	-1	-1
Lion (A), *P. leo*	I: 5 [2] (7) 0	M: 7.18	0	L: 126.0	-1	-1
Jaguar (A), *P. onca*	I: 4 [3] (7) 0	M: 8.91	0	L: 56.0	-1	-1
Asiatic golden cat, *C. temmincki*	I: 5 [3] (8) 0	S: 2.66	-1	M: 10.0	0	-1
Oncilla, *L. tigrinus*	N: 3 [1] (4) -1	S: 2.90	-1	S: 2.0	+1	-1
Rusty-spotted cat, *P. rubiginosus*	I: 7 [0] (7) 0	R: 0.78	-2	S: 1.5	+1	-1
Clouded leopard, *N. nebulosa*	I: 4 [4] (8) 0	S: 2.79	-1	M: 20.0	0	-1
Marbled cat, *P. marmorata*	N: 3 [1] (4) -1	S: 2.42	-1	S: 3.5	+1	-1
Category 4						
Sand cat, *F. margarita*	N: 2 [1] (3) -1	M: 5.40	0	S: 2.5	+1	0
Margay, *L. wiedi*	N: 2 [3] (5) -1	M: 6.06	0	S: 3.2	+1	0
Serval, *L. serval*	I: 7 [2] (9) 0	M: 8.18	0	M: 10.0	0	0
Canada lynx, *L. canadensis*	I: 4 [4] (8) 0	M: 5.06	0	M: 8.5	0	0
Geoffroy's cat, *O. geoffroyi*	I: 6 [1] (7) 0	S: 2.80	-1	S: 4.2	+1	0
Manul, *O. manul*	N: 4 [2] (6) -1	M: 5.08	0	S: 3.0	+1	0
Category 5						
Category 5a						
Puma (A), *P. concolor*	B: 8 [7] (15) +1	W: 17.12	+1	L: 41.0	+1	+1
Leopard (A), *P. pardus*	B: 10 [5] (15) +1	W: 23.14	+1	L: 40.0	-1	+1
Ocelot, *L. pardalis*	I: 5 [4] (9) 0	W: 12.45	+1	M: 8.8	0	+1
Eurasian lynx, *L. lynx*	B: 6 [6] (12) +1	W: 13.56	+1	M: 17.0	0	+1
Bobcat, *L. rufus*	B: 7 [4] (11) +1	M: 7.24	0	M: 7.5	0	+1
Pampas cat, *O. colocolo*	B: 4 [6] (10) +1	S: 3.86	-1	S: 3.4	+1	+1
Category 5b						
Caracal, *C. caracal*	B: 6 [4] (10) +1	W: 18.99	+1	M: 10.0	0	+2
Jungle cat, *F. chaus*	B: 8 [5] (13) +1	M: 8.49	0	S: 5.4	+1	+2
Leopard cat, *P. bengalensis*	B: 7 [5] (12) +1	M: 8.66	0	S: 2.4	+1	+2

Continued on next page

Species	Habitat Association St [Mar] (Tot) Score	Geog. Range (10^6 km^2)	Score	Body Size in kg	Score	Total Score
Category 5c						
Wildcat, *F. silvestris*	B: 8 [4] (12) +1	W: 34.17	+1	S: 3.5	+1	+3
Jaguarundi, *H. yaguarondi*	B: 6 [4] (10) +1	W: 13.53	+1	S: 4.4	+1	+3

Key:

Habitat Association
St = Number of strong + significant habitats
N = Narrow; I = Intermediate; B = Broad
[Mar] = Number of marginal habitats
(Tot) = Total number of habitats

Geographic Range
R = Restricted (< 1.5 million km^2)
S = Small (1.6 - 4 million km^2)
M = Medium (5-9 million km^2)
W = Wide (10-35 million km^2)

Body Size
L = Large; M = Medium; S = Small

(A) = Actively threatened

absent. For example: the sand cat is strongly associated with sandy desert; the lion is significantly associated with grassland and shrubland; the snow leopard is marginally associated with coniferous forest; and the Andean mountain cat is absent from broad-leaved humid forest.

The Habitat chapter describes how degree of association was determined, and Appendix 4 lists habitat associations for each species on both a global and regional level. For vulnerability ranking, species were scored as narrow, intermediate or broad in habitat association on the basis of the total number of habitat types in which a species occurs (strong, significant, or marginal).

Narrow habitat association (N): 2-6 habitat types (14 species). Score: -1.

Intermediate habitat association (I): 7-9 habitat types (12 species). Score: 0.

Broad habitat association (B): 10-15 habitat types (10 species). Score: +1.

Criterion 2. Geographic Range Size

Species with a restricted geographic range are more vulnerable to extinction than species with a wide range.

Range size was calculated (in millions of km^2) by comparing the range maps (Species Accounts) to the global habitat maps (Habitat chapter), applying reduction factors as necessary (for occurrence in only part of a given habitat type), and adding up the geographic area for each habitat type as derived from Olson *et al.* (1983). Only strong or significant habitat associations were used; habitats classified as marginal for a species were not included in the computation of its geographic range size. The methodology is described in greater detail in Appendix 4.

This exercise was undertaken only to derive a basis, more objective than a visual examination of distribution maps, for comparing species range size. However, for a variety of reasons the potential for error is high (see Appendix 4), and the figures given should not be treated as definitive. They appear in the worksheet summary of global cat species vulnerability rankings (Box 1) for comparative purposes, but are not given in the species accounts.

Restricted geographic range (R): <1.5 million km^2 (8 species). Score: -2.

Small geographic range (S): 1.6-4 million km^2 (10 species). Score: -1.

Medium geographic range (M): 5-9 million km^2 (9 species). Score: 0.

Wide geographic range (W): 10-35 million km^2 (8 species). Score: +1.

Criterion 3. Body Size

The larger an animal, the larger its home range, the lower its density, and the greater its local rarity.

A number of studies have found a general relationship between body size and density (Harestad and Bunnell 1979, Eisenberg 1980, Aritá *et al.* 1990). Within a given area (such as a nature reserve), big cats are expected to be more rare than small ones. Body size is thus a useful index to relative abundance (Soulé 1991), and it was included as a criterion to provide a link to species population size estimates, which are frequently requested. Average adult female weight was used to rank species in all but a few cases, when average weight (no gender specified) was used: these species were all small cats under 7 kg.

Large body size (L): 35-135 kg (7 species). Score: -1.

Medium body size (M): 7-20 kg (11 species). Score: 0.

Small body size (S): <6.5 kg (18 species). Score: +1.

Criterion 4. Active Threat

Widespread and uncontrolled hunting, which has the potential to remove animals from viable habitat in which they would otherwise be present, is an active threat to species.

Habitat loss and change are gradual, ongoing processes affecting all species, but widespread and uncontrolled hunting, which may be for food, sport, or trade, is an active threat to both cats and their prey. It is relevant primarily to the big cats. Their prey are mainly large ungulates, which are more vulnerable to over-hunting than rodents and other small mammals, on which small cats mainly subsist. Moreover, big cats are more likely to be commercially hunted and persecuted as problem animals. The suffix "A" is appended to the vulnerability rankings of all the larger

Box 2
1994 IUCN Threatened Species Categories (Groombridge 1993)

Extinct
Species not definitely located in the wild during the past 50 years.

Endangered
Taxa in danger of extinction and whose survival is unlikely if the causal factors continue operating. Included are taxa whose numbers have been reduced to a critical level or whose habitats have been so drastically reduced that they are deemed to be in immediate danger of extinction.

Vulnerable
Taxa believed likely to move into the "Endangered" category in the near future if the causal factors continue operating. Included are taxa of which most or all of the populations are decreasing because of overexploitation, extensive destruction of habitat or other environmental disturbance; taxa with populations that have been seriously depleted and whose ultimate security has not yet been assured; and taxa with populations that are still abundant but are under threat from severe adverse factors throughout their range.

N.B. In practice, "Endangered" and "Vulnerable" categories may include, temporarily, taxa whose populations are beginning to recover as a result of remedial action, but whose recovery is insufficient to justify their transfer to another category.

Rare
Taxa with small world populations that are not at present "Endangered" or "Vulnerable," but are at risk. These taxa are usually localized within restricted geographical areas or habitats or are thinly scattered over a more extensive range.

Indeterminate
Taxa *known* to be "Endangered," "Vulnerable," or "Rare," but where there is not enough information to say which of the three categories is appropriate.

Insufficiently Known
Taxa that are *suspected* but not definitely known to belong to any of the above categories, because of lack of information.

cats because of the relatively high levels of hunting pressure facing these species.

Scoring

The worksheet summary (Box 1) presents the scoring and vulnerability rankings of species on a global level. The higher the ranking, the higher the extinction risk. Within a category, actively threatened species ("A") are listed first because of their greater vulnerability. The more common and less vulnerable species (scores +1 to +3) were grouped under Category 5 (5a, 5b, 5c). This category is of lowest conservation priority on a global scale. However, regional rankings may differ. A summary of species vulnerability on a regional scale precedes each regional chapter of the Species Accounts.

Part I
Species Accounts

Chapter 1
Sub-Saharan Africa

Box 1
Vulnerability Index to Species of the Region (in order of vulnerability)

Species	Habitat Association St [Mar] (Tot) Score	Geog. Range (10^6 km^2)	Score	Body Size Score	Total Score	Ranking
Black-footed cat, *F. nigripes**	N: 3 [0] (3) -1	R: 0.95	-2	S +1	-2	1
African golden cat, *P. aurata**	N: 3 [2] (5) -1	S: 2.46	-1	M 0	-2	1
Cheetah, *A. jubatus**	I: 4 [4] (8) 0	M: 6.33	0	L -1	-1	2(A)
Lion, *P. leo**	I: 5 [2] (7) 0	M: 7.15	0	L -1	-1	2(A)
Serval, *L. serval**	I: 6 [2] (8) 0	M: 7.91	0	M 0	0	3
Leopard, *P. pardus*	B: 7 [3] (10) +1	W: 14.56	+1	L -1	+1	4(A)
Caracal, *C. caracal**	I: 5 [4] (9) 0	W: 11.93	+1	M 0	+1	4
African wildcat, *F. s. lybica* group	I: 6 [2] (8) 0	W: 16.80	+1	S +1	+2	5

Key:

*Most or all of this species' range lies within the region

Habitat Association
St = number of strong + significant habitats
N = Narrow (-1); I = Intermediate (0); B = Broad (+1)
[Mar] = number of marginal habitats
(Tot) = total number of habitats

Geographic Range (in millions of km^2)
R = Restricted (-2); S = Small (-1); M = Medium (0); W = Wide (+1)

Body Size
L = Large (-1); M = Medium (0); S = Small (+1)

(A) = Actively threatened

Regional Criteria
Habitat Association: Narrow = 3-5 habitat types; Intermediate = 7-9 habitat types; Broad = 10 habitat types
Geographic Range: Restricted = <1 million km^2; Small = 1-6 million km^2; Medium = 6-9 million km^2;
Wide = 9-17 million km^2
Body Size: Large = 35-135 kg; Medium = 7-20 kg; Small = <6.5 kg

See the Introduction to the Species Accounts for explanation of the vulnerability ranking system (pp. 2-6).

Black-footed cat, *Felis nigripes* Burchell, 1824

Other Names
Small spotted cat (English); chat à pieds noirs (French); Schwarzfusskatze (German); gato patinegro, gato de pies negros (Spanish); klein gekolde kat, swart poot kat, miershooptier [anthill tiger] (Afrikaans: South Africa); !koirus (Nama: Namibia); tutchu (Naron Bushman: Botswana); sebala, lototsi (Setswana: Botswana); ingwe yeziduli (Xhosa: South Africa).

Description and Behavior (Plate 3)
The black-footed cat is among the world's smallest felines, with females weighing around 1.2 kg (range 0.8-1.6) and males larger at 1.6-2.1 kg (Smithers 1971, Stuart 1981, Lynch 1983, A. Sliwa *in litt.* 1993). Total length ranges from 50-63 cm (Smithers 1971), and shoulder height is around 25 cm (Stuart and Wilson 1988). It is boldly patterned with blackish oblong spots, and its legs are barred with thick dark stripes. The undersides of its feet are black, like those of the African wildcat. The auditory bullae are enlarged, with total length about 25% of skull length (Skinner and Smithers 1990).

The diet consists mainly of small mammals and birds, and also includes arachnids, insects, and reptiles (Rautenbach 1978, Smithers 1971, Stuart 1981, Sliwa 1994). Radio-collared cats were observed by Sliwa (1994) to catch larks by stalking to within a short range and making a quick run and jump, catching some in the air as they flew off. Small rodents were caught by stalking or waiting (up to 30 min.) at holes. They also fed on emerging alates of the harvester termite, and caught larger winged insects such as grasshoppers. The largest mammal prey was an adult Cape hare, weighing as much as the adult female who caught it (1.5 kg). The largest bird caught was a small bustard, the black koorhaan, weighing 700 g. Black-footed cats have also been observed to eat black koorhaan eggs: "She flushed a female koorhaan from her nest, and then crushed the eggs gently between her jaws and licked their contents clean" (A. Sliwa *in litt.* 1994). Stuart (1981) reports a black-footed cat trapped with a guinea fowl carcass as bait. A. Sliwa (pers. comm.) has observed black-footed cats caching rodent and bird carcasses in hollows, returning after 2-14 hours to feed, and once observed a cat scavenging for four nights on a springbok lamb.

Most observations in the wild have been at night (Smithers 1971; P. Stander, J. Visser, pers. comm.). The cat observed by Sliwa (1993) was generally active between sunset and sunrise, and only during the cold winter months at first light and in late afternoon. The cat was active for most of the night, travelling an average of 8 km while foraging (n=10 nights). Black-footed cats lie up in disused burrows, such as those made by springhares, or in rocky crevices (Shortridge 1934, Sliwa 1993). Black-footed cats are apparently water-independent (Skinner and Smithers 1990). Unusually high blood levels of creatinine and urea (even for arid-adapted cats) have been found in both wild and captive black-footed cats (G. Olbricht and A. Sliwa, pers. comm. 1993). Olbricht and Sliwa have also noted that black-footed cats appear to have higher energy requirements than the larger African wildcats.

Biology
Birth season: (W) a pregnant female carrying two fetuses was collected in South Africa's Transvaal province in November (Rautenbach 1978). A kitten approximately one month old was observed in January in the northern Cape (A. Sliwa *in litt.* 1993); and two kittens were born in late February in a den in a hollow termite mound in the same area (A. Sliwa *in litt.* 1994).

Estrus: (C) 1-5 days (Leyhausen and Tonkin 1966, Mellen 1989).

Estrus cycle: (C) 54 days (Mellen 1989).

Gestation: (C) 63-68 days (Leyhausen and Tonkin 1966).

Litter size: (C) 1.71 ± 0.18 (n=9: Mellen 1989); range 1-2, rarely 3 (Visser 1977, Armstrong 1978).

Age at sexual maturity: (C) females 12 (Mellen 1989) -21 months (Leyhausen and Tonkin 1966); onset of spermatogenesis in males at about one year (R. Evans *in litt.* 1993).

Longevity: (C) up to 13 years (Green 1991).

Habitat and Distribution
The black-footed cat is restricted to the arid lands of southern Africa (Fig. 1). It is typically associated with open, sandy, grassy habitats with sparse shrub and tree cover, such as the Kalahari and Karoo regions (Smithers 1971, 1975; Visser 1977, Mills *et al.* 1984, Stuart and Wilson 1988, Sliwa 1993). A. Sliwa (pers. comm.) describes long grass with high rodent and bird densities as optimal habitat.

The northernmost records are from around 19° S in Namibia and Botswana (Shortridge 1934, Visser 1978, P. Stander, pers. comm. 1992), although the species may occur in the southwestern corner of Angola (Anstey 1992). It has not been recorded from Zimbabwe and Mozambique, although it probably occurs there marginally (Shortridge 1934, Dias 1966, Stuart and Wilson 1988, J. Visser *in litt.* 1993). A record for Malawi is erroneous (Ansell and Dowsett 1988).

Population Status
Global: Category 2. Regional: Category 1. IUCN: not listed. Most authorities have described the black-footed cat as a naturally rare species (Stuart and Wilson 1988,

Skinner and Smithers 1990). Shortridge (1934) reported at the turn of the century that mantles made from the skins of this species were expensive, "on account of their scarcity." Still, it is locally common at certain localities in South Africa, especially in the Orange Free State and northern Cape (J. Visser *in litt.* 1993). Being restricted to arid environments, it probably occurs at relatively low densities. An adult female observed for three months on a game farm near Kimberley (northern Cape, South Africa) had a home range of 12 km^2. A young male observed for a shorter period of time maintained a home range of 13 km^2, overlapping the female's range by about 50% (A. Sliwa *in litt.* 1993).

Protection Status

CITES Appendix I. National legislation: protected across most of its range. Hunting prohibited: Botswana, South Africa. No legal protection: Mozambique, Namibia, Zimbabwe (IUCN Environmental Law Centre 1986; P. Norton, C. Stuart *in litt.* 1993).

Principal Threats

Indiscriminate methods of predator control could be a significant threat, although farmers seldom report capturing black-footed cats in problem animal surveys (Joubert *et al.* 1982, Stuart and Wilson 1988). Farmers in South Africa and Namibia consider the similar-looking African wildcat a predator of small livestock, and set out steel-jaw traps and poisoned bait to get rid of them (Joubert *et al.* 1982, Vorster 1988). Carcass poisoning for jackal control could be a threat to the black-footed cat, which readily scavenges (A. Sliwa, pers. comm.). A similar threat is poisoning of locusts, which are food for the black-footed cat. Finally, overgrazing by livestock is prevalent throughout the

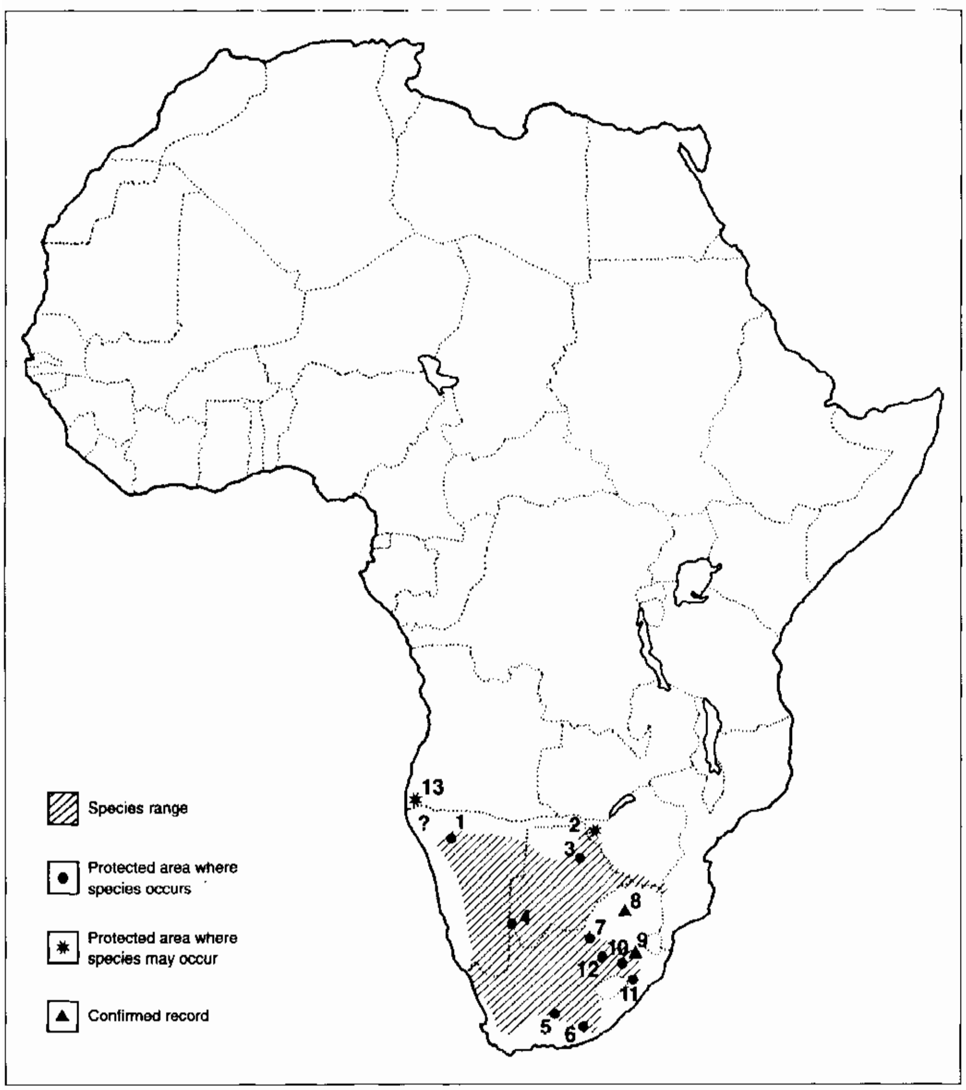

Figure 1. Distribution of the black-footed cat (*F. nigripes*). 1. Etosha II (Namibia); 2. Hwange II complex (Zimbabwe); 3. Makgadikgadi Pans IV (Botswana); 4. Gemsbok II (Botswana) + Kalahari Gemsbok II (South Africa) complex; 5. Karoo II; 6. Addo Elephant II; 7. Barberspan IV; 8. specimen collected at Marble Hall, Transvaal province (Skinner and Smithers 1990); 9. Kitten collected in northwestern Natal province (Rowe-Rowe 1992); 10. Royal Natal II; 11. Loteni IV; 12. Willem Pretorius IV (South Africa); 13. Iona VI (Angola).

species' range, and habitat deterioration can lead to reductions of the cat's small vertebrate prey base (A. Sliwa, pers. comm.).

Action Planning

Projects 18 and 19.

African golden cat, *Profelis aurata* (Temminck, 1827)

Other Names

Chat doré africain (French); Afrikanische Goldkatze (German); gato dorado (Spanish); gnaou ya zamba (Lingala: west Africa); lobwa, ebyo, ebie (Kota, Fang, Kwele: Gabon); embaka, ekinyange, semaguruet (Lukiga, Lukonjo, Kipsigi: east Africa); soukalan (Mandinka); osolimi, makolili, akalwa, egabasoti, esele, a'ka (Mbuti Pygmies: Zaire); donnou, dondou (Peul).

Description and Behavior (Plate 1)

The African golden cat is a medium-sized cat. Adult males weigh 11-14 kg (Van Mensch and Van Bree 1969, S. Lahm *in litt.* 1993). The only recorded weight of a wild female is 6.2 kg (Van Mensch and Van Bree 1969), but this was probably an immature animal. The African golden cat has both a reddish-brown and greyish color form, and its coat can be spotted or plain. Pocock (1907a) described an animal in the London Zoo whose color changed entirely from rufous to grey in four months. Van Mensch and Van Bree (1969) examined 186 pelts from various localities and found that 50% were of the red phase and 46% of the greyish phase, with 4% being totally black. While color phase appears variable across its range, they found that specimens taken from west Africa tended to be more spotted than those from east-central Africa, with the Zaire River forming an approximate boundary. The white underbelly is consistently marked with large black spots.

Despite a striking external similarity to the Asian golden cat, many authorities believe that the two species are not closely related (Van Mensch and Van Bree 1969, Hemmer 1978a, Wozencraft 1993; but see Fig. 3 under Taxonomy). The similarity of the golden cats may have resulted from convergent evolution in moist forest habitat, as there has been no direct forest connection between Africa and Asia for 20 million years (Groves 1982), but the relationship still deserves closer examination.

The African golden cat has never been studied and little is known of its behavior. It is reported to be primarily nocturnal and to rest in trees during the day (Rosevear 1974, Guggisberg 1975, Kingdon 1977, Happold 1987). Diurnal activity has also been noted (Kingdon 1977). It may hunt in trees to some extent (Basilio 1962, Kingdon 1977), but probably catches most of its prey on the ground (J. Hart and M. Katembo in prep.). Hart and Katembo analyzed 60 golden cat scats from Zaire's Ituri Forest, and found that 51% contained rodents and 20% ungulates. The rodents were mostly small species weighing less than 300 g. From carcass collections, they also note that scavenged eagle kills and predation on fallen, injured primates may be an important component of rain forest felid diets.

Hart and Katembo's data serve to balance anecdotal reports that golden cats prey mainly on small to mid-sized mammals, including tree hyraxes, the larger rodents (Basilio 1962, Brooks 1962, Rahm and Christiaensen 1963), and smaller forest antelopes (Van Saceghem 1942, Carpaneto and Germi 1989). On the contrary, they found small rodents to be more important. Other data on diet are patchy. For example, the stomach of one golden cat from Senegal contained the remains of a bird (Gaillard 1969), and Kingdon (1977) found the remains of red duikers, monkeys, rodents, and birds in scats examined from Uganda's Bwindi National Park. D. Jenny (pers. comm.) found many pangolin remains in scats in Taï NP, Ivory Coast. M. Agnanga (*in litt.* 1993) includes fish in the diet. Although there have been reports of predation on domestic animals, including chickens, goats, and sheep (Gyldenstolpe 1928, Bourdelle and Babault 1931, Kingdon 1977), such predation appears to be rather rare (E. Abe, M. Agnanga, B. Hoppe-Dominik, S. Lahm *in litt.* 1993).

Biology

Litter size: (W) According to the Mbuti Pygmies of northeastern Zaire, one (Carpaneto and Germi 1989). J. Hart and M. Katembo (in prep.) also found one nursing kitten in a fallen, hollow log. No other information.

Habitat and Distribution

The primary habitat of the African golden cat is the moist forest zone of equatorial Africa, including mangrove and alpine bamboo forests. Golden cats can penetrate savannah grasslands along belts of riverine forest (Van Mensch and Van Bree 1969), and so their distribution probably extends beyond the moist forest zone. As an extreme example, the species was recorded from Nioro du Sahel, Mali, in relatively arid savannah woodland (Bigourdan and Prunier 1937), although possibly in error (Van Mensch and Van Bree 1969).

Golden cats apparently adapt well to logged areas, as destruction of the canopy favors the dense secondary undergrowth with which they are often associated (Kingdon 1977, Anstey 1991, S. Lahm *in litt.* 1993). Edge environments generally contain higher rodent densities, and may thus be preferred (J. Hart *in litt.* 1994). However, primary forest with minimal human disturbance is the

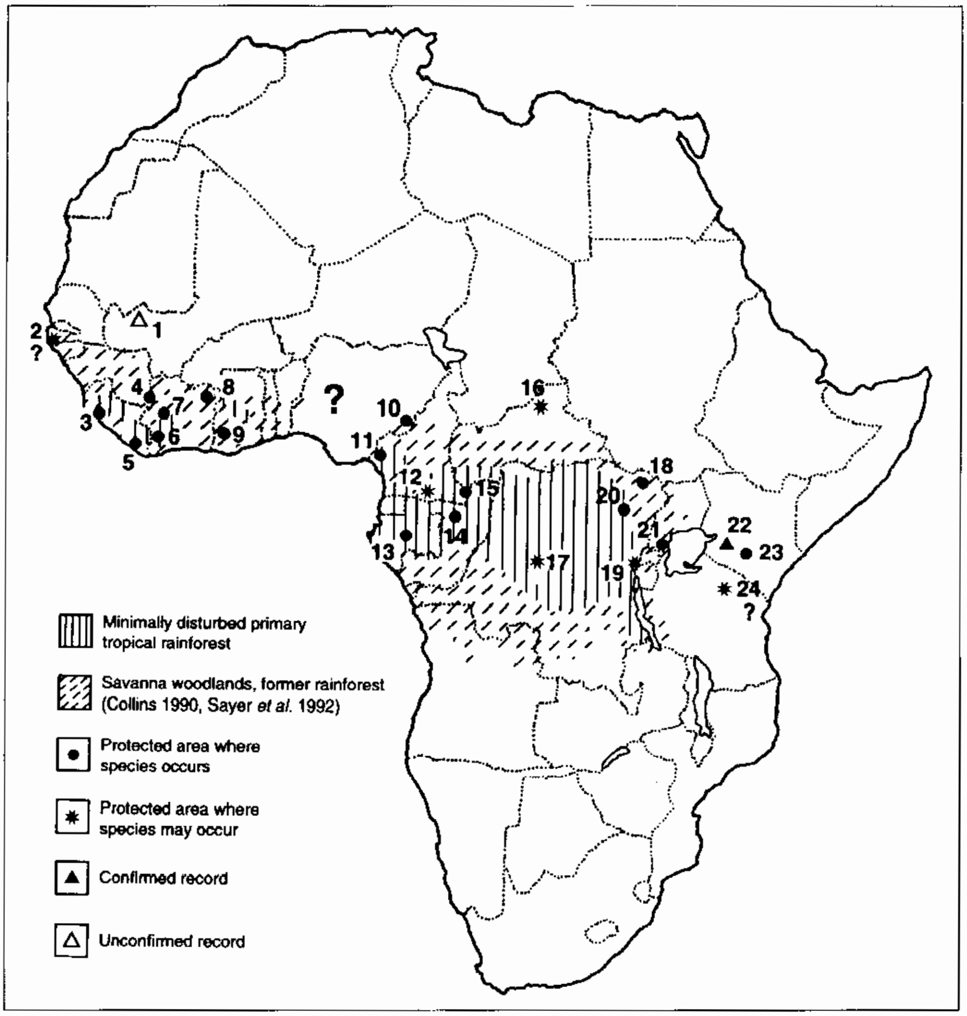

Figure 2. Distribution of the African golden cat (*P. aurata*). 1. Record from Nioro du Sahel, Mali (Bigourdan and Prunier 1937); 2. Basse-Casamance II (Senegal); 3. Gola Forest Reserve (Sierra Leone); 4. Mt Nimba I# complex (Ivory Coast and Guinea); 5. Sapo II (Liberia); 6. Taï II# complex; 7. Mt. Sangbe and Mt. Peko II; 8. Comoe II# (Ivory Coast); 9. Bia II (Ghana); 10. Gashaka-Gumti II (Nigeria); 11. Korup II; 12. Dja IV# (Cameroon); 13. Lope IV (Gabon); 14. Odzala II* complex (Congo); 15. Nouabale-Ndoki II (Congo) + Dzanga-Ndoki II complex (Central African Republic); 16. Manovo-Gounda-St. Floris II** complex (Central African Republic); 17. Salonga II; 18. Garamba II** complex (Zaire); 19. Virunga II** (Zaire) + Volcans II* (Rwanda) complex; 20. Reserve de Faune Okapi (Zaire); 21. Queen Elizabeth II* complex and Bwindi NP (Uganda); 22. Mau Escarpment (not protected) (G. Davies *in litt.* 1993); 23. Aberdare II (Kenya); 24. Ngorongoro Crater VIII# (Tanzania: IUCN 1987).

golden cat's fundamental habitat—M. Agnanga (*in litt.* 1993) reports that it is well known in northern Congo (among the most sparsely populated regions in tropical Africa), but not in the south, where the forests are semi-deciduous and partially logged (Sayer *et al.* 1992). Similarly, B. Hoppe-Dominik (*in litt.* 1993) describes the species as common in the Ivory Coast's Taï National Park (rain forest), but very rare in Comoe National Park (savannah woodland).

The golden cat has been recorded at elevations up to 3,600 m in Uganda (Guggisberg 1975), and in Kenya's Aberdare Mountains (Maberly 1966, Hardy 1979, Watson 1980). Figure 2, based on Van Mensch and Van Bree (1969), shows the tropical rain forest of the Zaire River basin as solid lines. Probable distribution elsewhere, including patches of wet montane forest and lowland humid forest interspersed with savannah grasslands (former rain forest: Collins 1990), is shown as dashed lines.

Population Status

Global: Category 2. Regional: Category 1. IUCN: Insufficiently Known. While the species is tied to moist forest habitats and is thus naturally rare, it is difficult to evaluate its conservation status due to lack of information on its biology and ecology. The moist forests of west Africa have been heavily degraded and remaining intact stands are patchily distributed, while those of the Zaire basin in Zaire, Congo, and Gabon are relatively pristine and large tracts of primary forest remain (Myers 1989, Collins 1990, Sayer *et al.* 1992). However, a large portion of the latter is inland swamp forest (Sayer *et al.* 1992), a habitat type in which the golden cat has not yet been recorded (S. Lahm *in litt.* 1993).

Small pieces of golden cat skin have totemic value "for wrapping things up in" (Van Mensch and Van Bree 1969, E. Gadsby *in litt.* 1991). Because of taboos, people may be reluctant to discuss the animal directly (Sanderson 1940).

Protection Status

CITES Appendix II. National legislation: Fully protected over only part of its range. Hunting prohibited: Angola, Benin, Burkina Faso, Congo, Ghana, Ivory Coast, Kenya, Liberia, Nigeria, Rwanda, Sierra Leone, Zaire. Hunting regulated: Gabon, Liberia, Togo. No domestic trade controls: Congo, Sierra Leone. No legal protection: Cameroon, Central African Republic, Gambia, Guinea Bissau, Senegal, Tanzania, Uganda. No information: Burundi, Guinea (IUCN Environmental Law Centre 1986; M. Agnanga, B. Hoppe-Dominik, S. Lahm *in litt.* 1993).

Principal Threats

Savannization in west Africa has probably led to population declines and fragmentation, unless there is migration along riverine corridors. The bush meat trade, which figures largely in the region's economy, may lead to local depletion of small antelope prey. There appears to be little hunting of golden cats (E. Gadsby *in litt.* 1991; S. Lahm, M. Agnanga *in litt.* 1993).

Action Planning

Projects 20 and 21.

Cheetah, *Acinonyx jubatus* Schreber, 1776

Other Names

Guépard (French); Gepard (German); guepardo, chita (Spanish); jagluiperd (Afrikaans: South Africa); abo shamani (Amharic: Ethiopia); fahd (Arabic); bogolo bogolo (Bournouan); marukopta (Burkina Faso); siho (Fufuldé: Cameroon); rabbi (Hausa); /uayb (Hei//kum Bushman: Namibia); !a'o (Ju/hoan Bushman: Botswana, Namibia); kisakasaka (Kasanga: Zaire); duma, msongo (KiSwahili); lengau, letlotse (Setswana: Botswana); dindingwe, ihlosi (Shona: Zimbabwe); haramacad, daharab, horkob (Somalia); ngulule (Zulu: South Africa).

Description and Behavior (Plate 2)

The cheetah is built for speed, with a deep chest, wasp waist, and proportionately longer limbs than the other big cats (Gonyea 1976). Average adult weight is 43 kg for males and 38 kg for females in the Serengeti (n=17: Caro *et al.* 1987). Flexion of the elongated spine has been measured as increasing the cheetah's stride length by 11% at speeds of 56 kph (Hildebrand 1959, 1961). The canines are small relative to other felids: a reduction in the size of roots of the upper canines allows a larger nasal aperture for increased air intake, which is critical for allowing the cheetah to recover from its sprint while it suffocates its prey by throttling it (P. Leyhausen in Ewer 1973, Kingdon 1977). Its claws remain exposed, lacking the skin sheaths found in most other felids, and thus provide additional traction like a sprinter's cleats. The foot shows several other modifications: the digital pads and also the metacarpal pad are extremely hard and pointed at the front, possibly as an adaption to sudden braking, and the palmar pads bear a pair of longitudinal ridges instead of the more usual slight depressions—the functional equivalent of tire treads, serving as anti-skid devices (Pocock 1916, Ewer 1973). The prominent dew claws are used as hooks to trip up fast-running prey. The long tail helps the cheetah's balance as it swerves during a chase. Finally, the cheetah has enlarged bronchi, lungs, heart, and adrenals (Eaton 1974).

According to K. Sevrin (pers. comm. in Eaton 1974: 24), a captive cheetah was accurately clocked at 112 kph over a short distance. In the wild, out of 78 chases measured and timed by G. Frame (Frame and Frame 1981: 181), the top speed was 87 kph. Antelopes, the main prey of cheetah, reach top speeds of 80-97 kph (Garland 1983), so peak speeds reached at some portion of a cheetah's sprint probably do exceed the oft-quoted, but seldom documented, 110 kph. Cheetah sprints rarely last longer than 200-300 m, while most antelope can run much further. Heat builds up rapidly during a sprint, and cheetahs have not evolved the evaporative heat release mechanisms of gazelles and goats, even though their energetic cost of running is equivalent (Taylor and Rowntree 1973, Taylor *et al.* 1974). Despite its refinements, the cheetah, like the other cats, is a sprinter rather than a courser.

Cheetahs are pale yellow with white underbellies, covered all over with small round black spots. They are readily distinguished from their spotted relatives by their "tear lines"—heavy black lines extending from the inner corner of each eye to the outer corner of the mouth. Both melanistic and albino cheetah specimens have been reported (Guggisberg 1975), and remarkably pale animals have been reported from desert regions (Dragesco-Joffé 1993, P. Gros *in litt.* 1993). A more notorious single-locus genetic mutation (Van Aarde and Van Dyk 1986) produces the blotched tabby pattern of the so-called king cheetah (Plate 2), which was once classified as a separate species (Pocock 1927), and was the subject of a major investigative expedition (Bottriell 1987). This mutation has historically been recorded only from a restricted area in southern Africa centered on Zimbabwe (Hills and Smithers 1980), but there is a recent report of a single skin recovered in Burkina Faso, west Africa (Frame 1992).

A greater degree of sociality has been observed among cheetahs than for most felids, with the exception of the lion. Male and female litter-mates tend to stay together for about six months after independence (Caro 1994). Nearly two decades of intensive research in the Serengeti Plains have shown that, while females split off upon reaching sexual maturity, male litter-mates remain together in coalitions, and sometimes defend territories (Frame and Frame 1984, Caro and Collins 1986). These coalitions, particularly trios, may include unrelated males, with the frequency of this type of grouping estimated at 15% in the Serengeti (Caro and Collins 1986). Males in coalitions are more likely than solitary males to gain and maintain territories; non-territorial males live a nomadic existence and wander widely (Caro and Collins 1986, 1987a). Territorial males were found to be in better physiological condition and appear to have better access to females during periods of gazelle concentration (Caro and Collins 1987b, Caro *et al.* 1989).

Large groups of up to 14-19 animals (including cubs) have been reported occasionally from parts of east and southern Africa where other large predators have been eradicated (Kenya: Graham 1966, P. Gros *in litt.* 1993; Botswana: Gros 1990; Namibia: McVittie 1979, Marker-Kraus and Kraus 1991). The advantages of grouping under such conditions are not clear (S. Durant *in litt.* 1993).

In east Africa, the cheetah's main prey is the Thomson's gazelle on the plains (Serengeti: Schaller 1968), and impala in the woodlands (Eaton 1974). In the arid bushland of northern Kenya, G. Adamson (in Hamilton 1986a) identified lesser kudu, gerenuk, and dik-dik as major prey. In southern Africa, major prey consists of springbok (northeast Botswana: Smithers 1971; Kalahari Gemsbok National Park, South Africa: Mills 1990a; Etosha NP, Namibia: unpubl. data); greater kudu calves and warthog (Namibian ranchland: Morsbach 1987, L. Marker-Kraus, pers. comm.); impala (Kruger National Park, South Africa: de Pienaar 1969, Mills and Biggs 1993); and puku (Zambia: Mitchell *et al.* 1965). Data are scarce for central and west Africa, but cheetahs have been observed to take red hartebeest, oribi, and kob in Manovo-Gounda-St. Floris National Park in the Central African Republic (Ruggiero 1991). Cheetahs are also known to take smaller prey, particularly hares (Frame 1977, Labuschagne 1979, 1981), and male coalitions often take much larger prey, such as wildebeest (Dorst and Dandelot 1969, Eaton 1974, McVittie 1979, Caro and Laurenson 1990, Skinner and Smithers 1990). Seasonally, a large proportion of cheetah prey captures consist of immature animals (McLaughlin 1970, Burney 1980). When hunting group-living prey animals, such as Thomson's gazelles, they tend to select less vigilant solitary individuals (FitzGibbon 1990).

Certain aspects of cheetah behavior can be explained as adaptations to compete with other sympatric large predators, particularly lions and hyaenas. Cheetahs are predominantly diurnal, probably because competing predators are nocturnal. It has been suggested that the cheetah's large litter size may be a strategy to offset high juvenile mortality caused by predators (Burney 1980, Hamilton 1986a, Laurenson 1992, Caro 1994). Cheetahs often lose their kills to lions and hyaenas, and have only rarely been observed to scavenge, or return to a previously abandoned kill (Graham 1966, de Pienaar 1969, Burney 1980, Caro 1982, Stander 1990a). There is preliminary evidence that cheetahs will remain near large kills, rather than abandon them after satiation, on Namibian ranchlands where lions and hyaenas have been eliminated (L. Marker-Kraus, pers. comm. 1994).

Biology

Reproductive season: (W) year-round, although birth peaks have been reported during the rainy season in the Serengeti (November-May: Frame 1977, Laurenson *et al.* 1992).

Gestation: (C) 90-98 days (Marker-Kraus 1992).

Litter size: (W) 4.2 (age 1-3 months) on Namibian ranchland (McVittie 1979); 3.5 (age 6-35 days; Laurenson *et al.* 1992) - 2.6 (age three months; Frame 1977) in the Serengeti; (C) 3.7 (Marker and O'Brien 1989), range 1-8 (Green 1991).

Interbirth interval: (W) 15-19 months (McLaughlin 1970, Schaller 1972). Females readily go into estrus and conceive after losing a litter. Laurenson *et al.* (1992) found that the interval between the death of the previous litter and the next successful conception was longer for young (86.3 days, n=3) than adult females (17.8 days, n=9).

Age at independence: (W) mean 18 months (Laurenson *et al.* 1992), range 13-20 months (Frame 1984) (sub-adults leave mother); 17-27 months (females leave sibling groups: Frame 1980, Laurenson *et al.* 1992).

Age at first reproduction: (W) females 24 (n=2: Schaller 1972) - 36 months (n=4: Laurenson *et al.* 1992); males 30-36 months (Caro 1991). (C) females 2-3 years (n=10); males 1 2 years (n=8) (McKeown 1992).

Age at last reproduction: (C) females 10 years; males up to 14 years (McKeown 1992).

Sex ratio: (W) cubs: 1 male:0.95 female (n=117); adults and independent sub-adults: 1 male:1.9 females (n=169). This suggests differential male dispersal and mortality (Frame and Frame 1984), although males can be shyer than females and more difficult to observe (Caro and Collins 1986).

Juvenile mortality: (W) Other large carnivores, as well as baboons (L. Marker-Kraus *in litt.* 1993), are known to kill cheetah cubs. In the Serengeti, the number of lions on the grassy plains which constitute the Serengeti Cheetah Project's study area have increased tenfold since the 1960s, following an increase in wildebeest after rinderpest control measures. Under such circumstances, cheetah cub mortality is very high: Laurenson (in press, pers.

comm. 1993) found that 73% of cub deaths were due to predation (mainly lion), and that a total of 95% of 125 cubs failed to survive to independence.

Longevity: (W) 12-14 years (Frame and Frame 1980). However, Laurenson (in press) estimates the mean life expectancy of females reaching three years of age in the Serengeti at only an additional 3.9 years. Territorial males probably live longer, on average, than single males (Caro and Collins 1986, Caro *et al.* 1989). (C) average 10.5 and up to 21 years (L. Marker-Kraus *in litt.* 1993).

Habitat and Distribution

Cheetahs are distributed primarily throughout the drier parts of sub-Saharan Africa (Fig. 3). They are not generally associated with forest habitats: they occur only thinly in the more humid zones of *miombo* woodland that cover much of central southern Africa, and are absent from the Sudano-Guinean forest savannah belt of west Africa (Myers 1975). However, although cheetahs are most frequently observed on open grassy plains (e.g. Schaller 1972, Mills and Biggs 1993), they also make extensive use of bush, scrub, and open woodlands (Myers 1975, Hamilton 1986a, Morsbach 1987). Observations by Eaton (1974) suggest that cheetahs expend more energy hunting in open country than in cover. A mosaic of woodland and grassland is probably preferred. They range up to 1,500 m in the mountains of Ethiopia (Yalden *et al.* 1980).

Cheetahs are well-adapted to living in arid environments. They are not obligate drinkers and, in the Kalahari desert, have been estimated to travel an average of 82 km between drinks of water. They were observed to satisfy their moisture requirements by drinking the blood or urine of their prey, or by eating tsama melons (Labuschagne 1979, 1981).

Population Status

Global: Category 3(A). Regional: Category 2(A). IUCN: Vulnerable. The total number of cheetahs in sub-Saharan Africa has been variously estimated at 15,000 (Myers 1975), 25,000 (Frame 1984), and 9,000-12,000 (Kraus and Marker-Kraus 1991), and a wide-ranging survey is in progress to develop a better grasp of the cheetah's current status (P. Gros, in prep.). The two largest metapopulations of cheetah are now believed to occur in east Africa (Kenya and Tanzania) and southern Africa (Namibia, Botswana, Zimbabwe and Zambia) (Kraus and Marker-Kraus 1991, Gros 1990 and *in litt.* 1991). The cheetah appears to be most rare in the Sahelian and Sudanian semi-arid zones of west Africa—although originally optimal habitat, much of it is now very degraded under human population pressures (T. Anada *in litt.* 1993). Cheetah populations are still believed to be healthy in Ethiopia, with their stronghold across the south of the country, and sightings have increased further north in Awash National Park, where a cheetah was killed by a train in 1992 (J. Hillman *in litt.* 1993).

Density and abundance vary widely according to environmental conditions, especially the occurrence of suitable prey and other large predators (Laurenson in press). In the Serengeti Plains ecosystem, cheetahs concentrate seasonally in association with migratory movements of Thomson's gazelle (Durant *et al.* 1988). Frame (1977) found dry season concentrations of one adult per 6 km^2 around woodlands/plain edge in the Serengeti. Based on individual recognition of cheetahs from photos taken by tourists, Bowland (1993) reported a low density for Kruger National Park of one adult per 191 km^2. Excluding cubs under three months of age, Burney (1980) found that total cheetah density was twice as high in pastoral areas outside the Masai Mara National Reserve (1/29 km^2) as inside the protected area (1/67 km^2). On Namibian ranchland, Morsbach (1987) reported a density of one cheetah per 50 km^2.

Estimating cheetah density is complicated by their unusual social organization. Both solitary male and female adults are semi-nomadic, having large, overlapping home ranges of the order of 800-1,500 km^2 (Frame 1980, Morsbach 1987, Caro 1994). Coalitions of males, on the other hand, have been found (in the Serengeti) to defend small territories of the order of 12-36 km^2, but up to 150 km^2 (Bertram 1978, Frame 1980, Caro and Collins 1986). These territories periodically hold high numbers of Thomson's gazelle, the favored prey of female cheetahs, and females were often observed in the males' territories (Caro and Collins 1987b).

Protection Status

CITES Appendix I. An Appendix I quota system was established under CITES in 1992 for live animals and trophies, with annual quotas allocated as follows: 150 (Namibia), 50 (Zimbabwe), 5 (Botswana). National legislation: fully protected over most of its range. Hunting prohibited: Angola, Benin, Botswana, Burkina Faso, Cameroon, Central African Republic, Ethiopia, Ghana, Kenya, Malawi, Mali, Mauritania, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, South Africa, Sudan, Tanzania, Togo, Uganda, Zaire. Trophy hunting permitted: Namibia, Zambia, Zimbabwe. No information: Chad, Sudan (IUCN Environmental Law Centre, 1986; Kraus and Marker-Kraus 1991).

Principal Threats

Genetic homogeneity: Genetic research has demonstrated that both captive and free-ranging cheetahs exhibit a very high level of homogeneity in coding DNA, on a par with inbred strains of laboratory mice (O'Brien *et al.* 1983, 1985, 1986, 1987a). The cheetah appears to have suffered a series of severe population bottlenecks in its history, with the first and most significant occurring possibly during the late Pleistocene extinctions, around 10,000 years ago (Menotti-Raymond and O'Brien 1993). The factors which would have led to these ancient population bottlenecks are not clear, but both their causes and consequences could be of significance to cheetah conservation today.

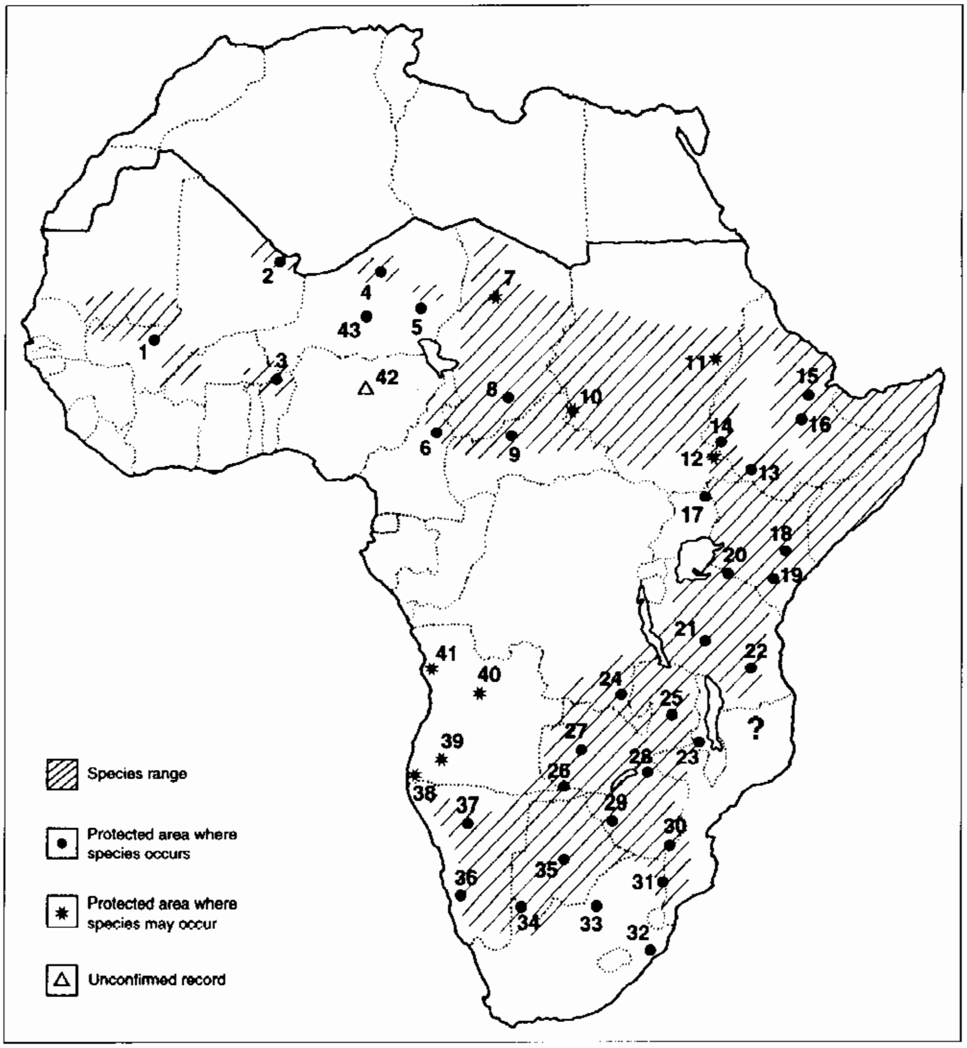

Figure 3. Distribution of the cheetah (*A. jubatus*) in sub-Saharan Africa.
1. Boucle du Baoule II complex; 2. Adrar des Iforas Mts Reserve (proposed: Mali); 3. "W" II* complex (Burkina Faso, Benin and Niger); 4. Aïr and Ténéré VIII; 5. Termit Massif (not protected) (Niger); 6. Benoue II* (Cameroon); 7. Ouadi Rime-Ouadi Achim Faunal Reserve; 8. Zakouma II complex (Chad); 9. Manovo-Gounda-St. Floris II** complex (Central African Republic); 10. Ouandjia-Vakaga IV (Central African Republic) + Radom II* (Sudan); 11. Dinder II* complex; 12. Boma II (Sudan); 13. Mago + Omo II complex; 14. Gambella V; 15. Yangudi Rassa II; 16. Awash II (Ethiopia); 17. Kidepo Valley II complex (Uganda); 18. Kora II complex; 19. Tsavo II complex (Kenya); 20. Maasai Mara II (Kenya) + Serengeti II# (Tanzania) complex; 21. Ruaha II complex; 22. Selous IV** complex (Tanzania); 23. Kasungu II (Malawi); 24. Kundelungu II complex (Zaire); 25. South Luangwa II complex; 26. Sioma Ngwezi II; 27. Kafue II complex (Zambia); 28. Mana Pools II** complex; 29. Hwange II complex; 30. Gonarezhou II (Zimbabwe); 31. Kruger II complex; 32. Hluhluwe/Umfolozi IV and other Natal reserves; 33. Pilanesberg II (reintroduced) (South Africa); 34. Kalahari Gemsbok II (South Africa) + Gemsbok II (Botswana) complex; 35. Central Kgalagadi II (Botswana); 36. Namib-Naukluft II; 37. Etosha II (Namibia); 38. Iona VI; 39. Bikuar II; 40. Luando IV; 41. Kisama V (Angola); 42. The cheetah is considered very rare if not extirpated in Nigeria, but there was a recent sighting from Falgore (Kogin Kano) IV (F. Hurst *in litt.* 1994); 43. Gadabedji IV (Niger).

It has been argued that lack of genetic diversity may render the cheetah an exceptionally vulnerable species (O'Brien *et al.* 1983). Genetic variation is thought to be essential to the long-term adaptability and persistence of populations by providing sufficient genetic options on which natural selection can operate in response to environmental change. The evidence for cheetahs being compromised by their genes arises mainly from captivity, where epidemics of infectious disease have occurred with high mortality (O'Brien *et al.* 1985, Evermann *et al.* 1988). Increased susceptibility to disease has been linked to genetic monomorphism (O'Brien and Evermann 1988). Zoos have had great difficulty in breeding cheetahs. Captive female cheetahs conceive infrequently, and when they do, cub mortality is relatively high (28-36%) (Marker and O'Brien 1989; Marker-Kraus and Grisham 1993), although these rates are similar to those of other felid and carnivore species kept in captivity (Loudon 1985). Finally, both wild and captive male cheetahs have high levels of abnormal sperm (71-76%: Wildt *et al.* 1987a), and success with *in vitro* fertilization using cheetah sperm is relatively low compared to other felid species (Donoghue *et al.* 1992).

However, there is no evidence that reproduction is compromised in the wild (Caro and Laurenson 1994). To a large extent, the cheetah's poor reproductive performance in captivity is linked to institutional management practices. First, some zoos have had high success in breeding cheetahs (Van Dyk 1991, Lindburg *et al.* 1993). Factors which appear to facilitate breeding include large enclosures with long views, constant separation and reintroduction of males and females, and provision of secluded nest boxes for mothers with young (Lee 1992, Laurenson 1993). Second, vulnerability to disease increases in captive situations, and no epidemics have been reported from wild populations, although cheetahs in some parks have been reported to suffer a relatively high incidence of mange (Caro *et al.* 1987, Bowland 1993, R. Kock *in litt.* 1993). Finally, some captive males are very fertile and others essentially infertile, despite having similar levels of poor quality sperm (Donoghue *et al.* 1992, Lindburg *et al.* 1993, Wildt *et al.* 1993a).

The cheetah's genetic monomorphism is a fascinating aspect of its biology, and potentially of importance to its conservation, but implications for management of wild populations are not yet evident.

Vulnerability in Protected Areas: Many observers have commented on the cheetah's vulnerability to interspecific competion with other large carnivores, and this is now the primary focus of the long-term cheetah study in the Serengeti (S. Durant, pers. comm. 1993). The chief mechanism by which more powerful carnivores—lions, leopards, and hyaenas—limit cheetah abundance is by killing cheetah cubs (Laurenson in press), but these species, as well as (sometimes) jackals, baboons, and vultures, also drive adult cheetahs off their kills. The cheetah's relatively large litter size may be a strategy to offset high juvenile mortality (Burney 1980, Hamilton 1986a, Laurenson 1992, Caro 1994). Where other large carnivores have largely been eliminated, such as ranchland in Namibia, farmland and pastoral land in Kenya, and in parts of Somalia, cheetahs appear to flourish at higher densities (McVittie 1979, Burney 1980, Hamilton 1986a, Morsbach 1987, A. Simonetta *in litt.* 1993). A strategy of relying solely upon the limited system of protected areas within the cheetah's range may not be sufficient to ensure the conservation of viable sub-populations.

Livestock Predation: The survival of the cheetah outside protected areas is affected by conflicts with people over predation on livestock. Cheetahs are reported to prey on young camels and goats in the Aïr and Termit regions of Niger (T. Anada *in litt.* 1993). In Namibia, the cheetah is viewed as the most important predator of livestock on both commercial and communal farms: annual losses for these farms have been reported at 10-15% for small stock (sheep and goats) and 3-5% for cattle calves up to eight months of age (Morsbach 1984-1986). Inevitably, stock losses to predators are greater where the natural prey base has been eliminated or reduced: on a 200 km^2 ranch in Kenya, where about 9,500 head of livestock graze alongside a still largely intact wild ungulate assemblage, depredation by cheetahs is minimal, accounting for only 11 sheep a year (Mizutani 1993).

Although farmers' estimates of stock losses to cheetah may be inflated, either intentionally or otherwise, the fact remains that the species is widely considered a threat to people's livelihood, and governments have little hope of preventing the destruction of cheetah on private lands if that is what the owners wish to do. Hamilton (1986a) points out that the cheetah may be more resilient to eradication on ranchland than other large carnivores—which will, for example, take poisoned bait—but the cheetah's decline on Namibian ranchland during the 1980s is certainly attributable to persecution (Morsbach 1987). Namibia, South Africa, and Zimbabwe are now pursuing a strategy of permitting trophy hunting of cheetahs on private land, with the goal of encouraging landowners to accept and profit from cheetahs on their land. In addition, the Cheetah Conservation Fund of Namibia is working to educate farmers about appropriate management steps that can be taken to minimize stock losses (see Part II Chapter 2).

Action Planning

Projects 22-27.

African lion, *Panthera leo* (Linnaeus, 1758)

Other Names

Lion d'Afrique (French); Löwe (German); león (Spanish); ambessa (Amharic: Ethiopia); nkharam (Chichewa: Malawi); xamm (Damara: Namibia); zaki (Hausa); odum, aja (Ibo, Yoruba: Nigeria); n!hai (Ju/hoan Bushman: Botswana, Namibia); ngatia, muruthi (Kikuyu: Kenya); ngouambulu (Lingala: west Africa); labwor (Luo: Kenya, Uganda); olugatany (Maasai, Samburu: Kenya, Tanzania); leao (Portugese); tau (Setswana: Botswana); simba (KiSwahili); aar, baranbarqo, libaax, gool, davar (Somalia).

Description and Behavior (Plate 1)

Smuts (1976) reports the following weight series for lions in South Africa's Kruger National Park: adult males (>4 years) 181 kg (n=14) and females 126 kg (n=25); sub-adult males (2-4 years) 146 kg (n=25) and females 103 kg (n=11); large male cubs (1-2 years) 77 kg and females 60 kg. The largest adult male weighed 225 kg, and the largest female 152 kg (Smuts 1982). A male shot near Mount Kenya in 1993 weighed 272 kg (R. Kock *in litt.* 1993). The record total lengths (including the tail) for male lions are around 3.3 meters (Guggisberg 1961). Lions have uniformly tawny coats. While the color may vary locally from pale to dark, leucism (unusual white pelage but with pigmented eyes and skin, as opposed to true albinism which is a complete lack of pigmentation) has been reported only from the vicinity of Kruger National Park and the Umfolozi Game Reserve in South Africa (McBride 1977, Smuts 1982), and a black form has never been observed (Guggisberg 1975). Lions are the only cats with tufted tails and manes (males only). The mane appears to serve several functions: increased protection during intraspecific fighting; a signpost of gender distinguishable at distance (possibly linked to the lion's historic colonization of open plains); and an indicator of individual fitness (Schaller 1972, Kingdon 1977). The males of many polygynous species tend to develop conspicuous display features. The fact that only the lion, out of all cats, has done so suggests that the mane is closely linked to the lion's distinctive social system. Mane development is strongly influenced by testosterone (Schaller 1972).

The core unit of the lion's matrilocal society is the pride, which consists of a group of related females (none dominant) and their cubs (Schaller 1972, Bertram 1975a, Packer *et al.* 1991a). There are only two recorded cases of unrelated females forming a pride, and both cases involved prides giving up their original natal ranges: the first when prolonged severe drought in Botswana's Central Kalahari Game Reserve rendered the females' original ranges uninhabitable (Owens and Owens 1984), and the second when extensive culling of lions in the Kruger National Park opened up large vacancies for immigration (Smuts 1978a). Pride sizes (measured by the number of adult females) are smallest in very arid environments (mean 2.2 in South Africa's Kalahari Gemsbok National Park: Eloff 1973a) and otherwise average between four and six (Schaller 1972, Smuts 1976, Hanby and Bygott 1979, Ruggiero 1991, Stander 1991). Pride size is positively correlated with lean season prey abundance, and in the Ngorongoro Crater, where prey is abundant year-round, groups of up to 20 adult females have been observed (van Orsdol *et al.* 1985).

Prides are "fission-fusion" social units: membership is stable (for example, three prides in the Serengeti have occupied the same ranges for more than 20 years), but the pride members are often scattered in small sub-groups throughout the pride's range, and each individual spends a considerable amount of time alone (Schaller 1972, Bertram 1978, Pusey and Packer 1987). Females demonstrate several cooperative behaviors unique among the felids. Pride members often give birth in synchrony, and the young are reared communally, with cubs suckling freely from lactating females (Schaller 1972, Rudnai 1974, Bertram 1975b). Groups of females do most of the hunting, and males, for the short time that they are living together with females, concentrate their energy on defending their tenure (see below). Stander (1992a) found that males in Namibia's Etosha National Park failed to participate in hunts in 96% of 461 opportunities.

In general, prides often divide into smaller sub-groups when foraging (range 1-7: Stander 1992a, Scheel 1993). Stander (1992b) found a complex division of labor among hunting lionesses, with individuals repeatedly playing the same role of either "center" or "wing." Centers, which tended to be larger and heavier lionesses, generally ambushed and captured prey chased by the wings. However, lionesses were flexible and would switch roles, depending on group composition and positioning. D. Joubert (*in litt.* 1993) suggests that lionesses also switch roles according to prey type: in Botswana's Savuti National Park, he has observed, "with some consistency," the same lioness take the lead in warthog hunts, while playing a passive role in buffalo hunts.

A single male or coalition of males (up to seven) holds tenure over one or more prides, and effectively excludes strange males from siring cubs with pride females (Packer *et al.* 1991a). Competition among males for pride tenure is intense, and average tenure is only two (Packer *et al.* 1988) to three years (Stander 1991). Males will only seek tenure over or breed with related pride females under unusual circumstances (e.g.when the population is small and there are barriers to dispersal: Pusey and Packer 1987, Packer *et al.* 1991a,b). Males are also highly social: coalitions in the pre- and post-tenure periods hunt and scavenge cooperatively, and larger coalitions of 4-6 males can maintain tenure more than twice as long as 1-2 males (> 47 months) (Bygott *et al.* 1979).

Despite maternal defense, infanticide is common when males take over a new pride: most females with dependent offspring lose their cubs within a month of a takeover, and those that are pregnant lose their cubs shortly after giving birth. In this way, males assure paternity during their short reproductive lifetime, which is generally only as long as their period of pride tenure. In response, females show a burst of heightened sexual activity for about three months following a takeover, attracting other males and encouraging competition that ensures that the fittest (often largest) coalition is able to gain tenure. They remain infertile (anovulatory: Smuts *et al.* 1978) during this "testing" period, and only afterwards, when tenure has stabilized, tend to breed in synchrony (Packer and Pusey 1983). Litters born synchronously have a higher survival rate (probably due to maximal maternal care [Bertram 1975b]), and tend to show a sex ratio biased toward males. This may be because groups of related males reproduce more successfully (Pusey and Packer 1987).

Coalitions of >4 males are always related (being born in the same pride, but not necessarily of the same mother), while pairs frequently consist of unrelated males (and less frequently, a related pair teams with an unrelated male to form a trio) (Packer *et al.* 1991a). Reproductive success increases with coalition size (Bygott *et al.* 1979, Packer *et al.* 1988). Although at least one member of male coalitions larger than two fails to breed successfully (Packer *et al.* 1991a), through kin selection (Bertram 1976) non-breeding helpers which are related still ensure that some portion of their genes are passed down.

The question of why sociality evolved to such a high degree in lions has been the subject of considerable debate. There were probably several contributory causes, which occurred many generations ago. Data from present-day studies cannot refute any of them, but can shed some light on how and in what circumstances they might work (B. Bertram *in litt.* 1993). Evidence suggests that coordinated group hunts are more successful at capturing (Packer and Ruttan 1988, Stander 1992a,b) and killing (Packer 1986) very large prey (see below for discussion of major prey species). Stander and Albon (1992) found that hunting success, even for smaller antelope prey, increased linearly with foraging group size in the semi-arid open plains of Etosha National Park. However, what would seem to be the most obvious explanation—increased hunting success yields more food—becomes less so on closer examination. Even on large carcasses, it appears that the presence of numerous non-hunting "cheaters" (Packer and Ruttan 1988) within the pride can reduce per capita food intake to the point where cooperative hunting does not appear to be economic for the hunters. The highest rate of food intake per hunt appears to be gained by solitary females (Packer 1986). Packer (1986), based on the theory of kin selection, argued that lions became social because it is evolutionarily more advantageous to share kills with scavenging relatives than to yield to strange lions or other large predators. Other benefits of sociality have also been pointed out: defense of young, maintenance of long-term territories (Packer *et al.* [1990]), insurance against individual injury or incapacity, and minimization of chances of getting no food at all (B. Bertram *in litt.* 1993).

Major large ungulate prey species recorded in east, central, and southern Africa include buffalo, zebra, wildebeest, roan, sable, springbok, gemsbok, kob, impala, warthog, waterbuck, and hartebeest (Mitchell *et al.* 1965, Makacha and Schaller 1969, de Pienaar 1969, Schaller 1972, Eloff 1973a, Rodgers 1974, Rudnai 1974, Bertram 1978, Berry 1981, van Orsdol 1982, 1984, Smuts 1982, McBride 1984, Mills 1984, Fagotto 1985, Prins and Iason 1989, Ruggiero 1991, Stander 1992a, Scheel 1993, Viljoen 1993). While medium to large-sized ungulates make up the bulk of their diet, lions, like leopards, are generalist hunters, and will take a wide range of prey, from small rodents (Eloff 1973a) to young rhinos, hippos, and elephants (McBride 1990, Ruggiero 1991, Viljoen 1993; H. Dublin, H. Jachmann *in litt.* 1993). Individual differences in prey selection and killing techniques are often discernible for different prides in the same area (Rudnai 1973, van Orsdol 1984, McBride 1990, Mills and Biggs 1993), indicating a strong role for learning in the lion's hunting behavior. For example, a pride of lions which occasionally foraged along Namibia's Skeleton Coast desert learned how to prey and scavenge upon Cape fur seals (Bridgeford 1985, Berry 1991a). (The entire pride was eliminated in 1991 by cattle herdsmen [Berry 1991b., L. Scheepers, pers. comm. 1993]). Lions (especially males) frequently scavenge (>40% of food items in the Serengeti: Packer *et al.* 1990), although this behavior is less common in arid environments, where prey occurs at lower density (4.6 [Mills 1990) - 6% [Stander 1992a] of food items).

Lions usually (but not always) hunt at night (Schaller 1972, van Orsdol 1982, Mills and Shenk 1992, Stander 1992a). In Botswana's Savuti National Park, D. Joubert (*in litt.* 1993) reported a higher success rate when lions hunted on moonless nights. Their distinctive roar, which in optimal conditions can be heard up to five km away (Guggisberg 1975), appears to serve to demarcate territories (Schaller 1972), much as scat deposits do for the other large cats. Stander and Stander (1987) found it possible to distinguish between not only the roars of males and females, but also of individual males.

Outside protected areas, where lions are heavily persecuted and the wild ungulate prey base is reduced, group sizes are reported to be much smaller (1-2: Thomas 1990, F. Hurst *in litt.* 1991), and they are seldom heard to roar

(Thomas 1990, C. Stuart *in litt.* 1991). It is not clear whether the lion's social system "breaks down" under such conditions of low prey and low lion density. Small foraging group size may be more efficent for stock-raiding—larger groups would be more conspicuous and vulnerable to rancher retaliation (H. Dublin, C. Packer *in litt.* 1993).

Biology

Reproductive season: (W) Largely aseasonal (Bertram 1975b), but weak (February-April: Smuts *et al.* 1978) and strong (March-July: Packer *et al.* 1990) birth peaks recorded in Kruger and Serengeti National Parks.

Estrus: (W) 4 days.

Interestrus interval: (W) 16 days (Packer and Pusey 1982).

Gestation: (C) mean 110 days (range 100-114; n=51) (Cooper 1942).

Litter size: (W) from field counts of small cubs < 1 year of age, average 2.5 (n=59, Serengeti NP: Bertram 1975b) - 3.02 (n=47, Kruger NP: Smuts *et al.* 1978); range 1-6, but 98% of litters are 1-4 (n=274, Serengeti NP: Packer and Pusey 1987).

Interbirth interval: (W) mean 20 months (range 11-25; n=38) if previous litter survives to maturity (12 months); 4-6 months if previous litter lost (Pusey and Packer 1987).

Age at dispersal: (W) Males generally leave their natal pride at between 2-4 years (Schaller 1972, Bertram 1975a, Pusey and Packer 1987), but young males may be forced out much earlier by a pride takeover, e.g. 13-20 months (Hanby and Bygott 1987). Most young females are incorporated into their natal prides, but about 33% disperse to form new prides in the Serengeti (Pusey and Packer 1987). The percentage of dispersers may be higher elsewhere (D. Joubert *in litt.* 1993). Median age at dispersal for females is 2.5 years (75% of dispersers between 1.5-3.75 years of age: C. Packer *in litt.* 1993).

Age at first reproduction: (W) While the onset of spermatogenesis begins at 30 months in males (Smuts *et al.* 1978), and females may begin mating at 24 months, successful first reproduction generally happens only when pride membership is established. In the Serengeti, females which remained within their natal pride first gave birth at five years (n=22). Females which dispersed from their natal pride first successfully raised litters at an average age of 8 years (n=8 emigrant cohorts); earlier litters generally did not survive. Males generally establish pride tenure at 4-4.5 years, with larger coalitions (4+) establishing residence earlier (Pusey and Packer 1987).

Cub mortality: (W) Mortality of cubs is rather high in lions, and is linked chiefly to periods of prey scarcity, when kills may be more infrequent and cubs may not be able to eat well from group-shared carcasses (Schaller 1972, van Orsdol *et al.* 1985). Infanticide is also an important factor (Packer and Pusey 1983). Van Orsdol *et al.* (1985) reviewed cub mortality (< 12 months) across a range of habitats: rates ranged from 14-73%.

Sex ratio: (W) Prenatal: 1 male:0.9 female (n=39); adult (5+ years): 1 male:2.1 females (n=373 lions, Kruger NP: Smuts 1978b). Adult sex ratios are typically heavily weighted in favor of females. The skew does not appear to be related to food supply or density, but rather to differential rates of maturation, mortality, and emigration between the sexes (van Orsdol *et al.* 1985).

Age at last reproduction: (W) female reproductive performance starts to decline at 11 years and virtually ceases at 15 (Packer *et al.* 1988); 16 year-old males can still produce viable sperm (Smuts *et al.* 1978), but reproduction probably completely ceases after pride tenure is lost (8-10 years: Packer *et al.* 1988).

Longevity: (W) males generally 12 (Hanby and Bygott 1991), and up to 16 years (Smuts *et al.* 1978), females generally 15-16 (Hanby and Bygott 1991), and up to 18 years (Bertram 1975a); (C) average 13 years, but up to 25-30 (Guggisberg 1975).

Habitat and Distribution

Optimal habitat appears to be open woodlands and thick bush, scrub, and grass complexes where sufficient cover is provided for hunting and denning. The lion has a broad habitat tolerance, absent only from tropical rain forest and the interior of the Sahara desert. Although lions drink regularly when water is available, they are capable of obtaining their moisture requirements from prey and even plants (such as the tsama melon in the Kalahari desert), and thus can survive in very arid environments (Eloff 1973b). They may range quite high into the mountains of east Africa, up to 3,600 m on Kenya's Mt. Elgon (Guggisberg 1961), and 4,240 m in Ethiopia's Bale Mountains (Yalden *et al.* 1980).

The lion formerly ranged from northern Africa through southwest Asia (where it disappeared from most countries within the last 150 years), west into Europe, where it apparently became extinct almost 2,000 years ago, and east into India (where a relict population survives today in the Gir Forest: see species account in *North Africa and Southwest Asia*) (Guggisberg 1961). Lions survived in the desert on the edge of Niger's Aïr Mountains up to about 60 years ago (Rosevear 1974).

Population Status

Global: Category 3(A). Regional: Category 2(A). IUCN: not listed. There are no sound estimates of the total number of lions in Africa: guesstimates range from 30,000 to

100,000 (Stuart 1991, P. Jackson, pers. comm.). East and southern Africa are home to the majority of the continent's lions; in west Africa, numbers have greatly declined. Throughout most of Africa, lions are becoming increasingly rare outside protected areas (Fig. 4).

The countries in which lions are still relatively widespread are Botswana, Central African Republic, Ethiopia, Kenya, Tanzania, Zaire, and Zambia. Status in Angola,

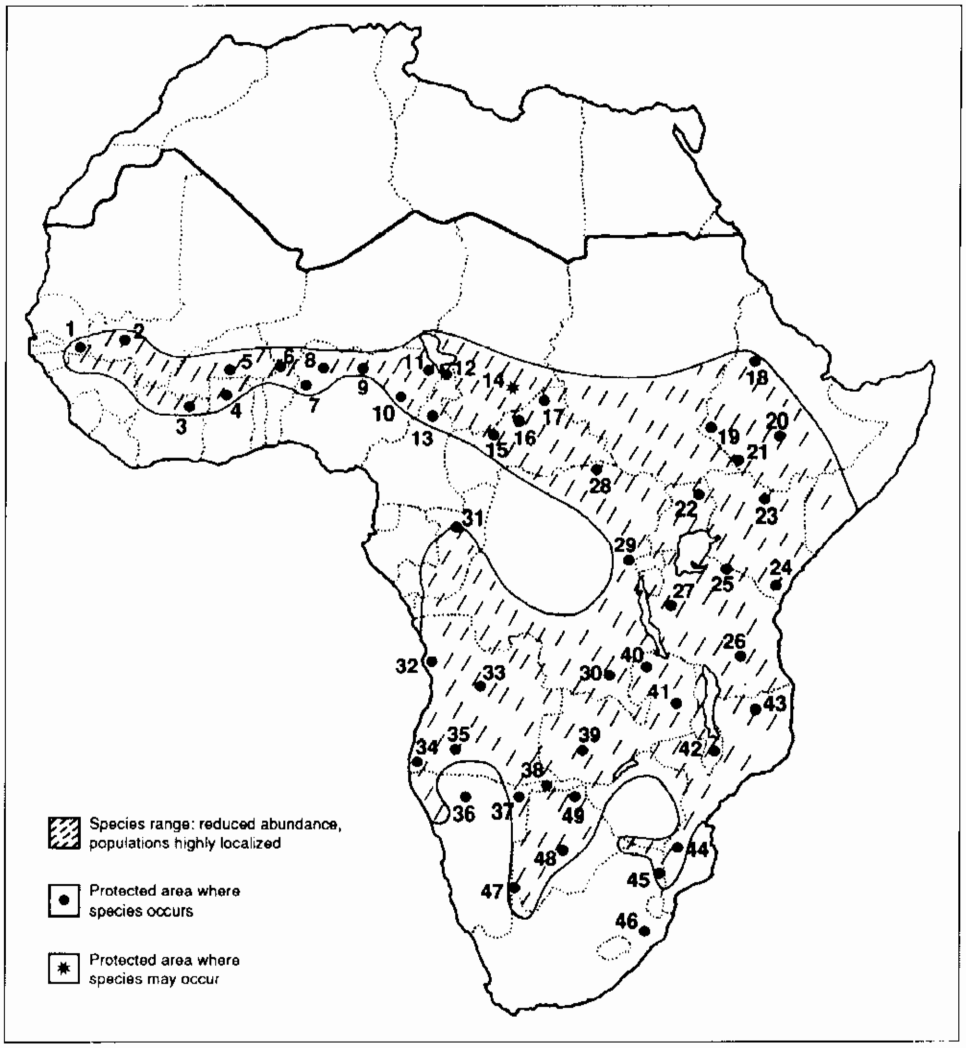

Figure 4. Distribution of the lion (*P. leo*) in sub-Saharan Africa.
1. Niokola-Koba II# (Senegal); 2. Boucle de Baoule II complex (Mali); 3. Comoe II# (Ivory Coast); 4. Mole II (Ghana); 5. Kabore-Tambi II (Burkina Faso); 6. "W" II* complex (Burkina Faso, Benin and Niger); 7. Kainji Lake II; 8. Kwiambana VIII complex; 9. Lame/Burra IV complex; 10. Yankari II; 11. Chingurmi/Duguma Game Reserve (Nigeria); 12. Waza II*; 13. Benoue II* (Cameroon); 14. Zakouma II complex (Chad); 15. Nana-Barya IV; 16. Bamingui-Bangoran II* complex; 17. Manovo-Gounda-St. Floris II** complex (Central African Republic); 18. Simien Mts. II**; 19. Gambella V; 20. Bale Mts. II; 21. Mago + Omo II complex (Ethiopia); 22. N and S Karamoja VI complex (Uganda); 23. Sibiloi II; 24. Tsavo II complex (Kenya); 25. Maasai Mara II (Kenya) + Serengeti II# (Tanzania) complex; 26. Selous IV** complex; 27. Moyowosi IV (Tanzania); 28. Bili-Uere VI; 29. Virunga II** complex; 30. Upemba II + Kundelungu II complex (Zaire); 31. Odzala II* complex (Congo); 32. Kisama II; 33. Luando IV; 34. Iona II; 35. Bikuar II (Angola); 36. Etosha II; 37. Kaudom VIII; 38. West Caprivi IV (Namibia); 39. Kafue II complex; 40. Mweru-Wantipa II complex; 41. N and S Luangwa II complex (Zambia); 42. Liwonde II (Malawi); 43. Rovuma (Niassa) Game Reserve; 44. Banhine NP (Mozambique); 45. Kruger II complex; 46. Hluhluwe-Umfolozi IV complex (South Africa); 47. Gemsbok II (Botswana) + Kalahari Gemsbok II (South Africa) complex; 48. Central Kgalagadi II complex; 49. Chobe II (Botswana).

Mozambique, Sudan, and Somalia is difficult to determine because of these countries' long history of civil unrest; in Angola lions are believed to be widespread but rare (Anstey 1992), and in Somalia they are patchily distributed, and largely restricted to the south (Fagotto 1985, A. Simonetta *in litt.* 1992).

Populations are well-defined, but isolated and centered on protected areas in the following southern African countries: Namibia (Etosha NP 300; northeastern region 130-200; Caprivi Strip 40-60; northwestern region 35-40 [H. Berry, P. Stander *in litt.* 1991]) and Zimbabwe (Hwange National Park complex 500; Gonarezhou National Park complex 200; Zambezi Valley and Sebungwe complexes 300 [Stuart and Wilson 1988]).

Lions are more sparsely distributed in Benin, Burkina Faso, northern Cameroon, southern Chad, southern Congo, northern Ivory Coast, northern Ghana, northern Guinea, eastern Guinea Bissau, southern Mali, northern Nigeria, and Uganda. Populations are essentially restricted to protected areas only in Burundi, Malawi, Niger, Rwanda, Senegal, and South Africa. Lions are believed to be extinct or practically so in Djibouti, Gabon (Franceville area), Lesotho, Mauritania, Swaziland, and Togo (Limoges 1989, Stuart 1991; E. Abe, M. Agnanga, T. Anada, A. Blom, P. Chardonnet *in litt.* 1993).

Reported lion densities (measured according to numbers of adults and sub-adults per 100 km^2) range from 0.17 in the Savuti region of Botswana's Chobe National Park (Viljoen 1993) to 1.5-2 (Kalahari Gemsbok NP: Mills *et al.* 1978; Etosha NP: Stander 1991) to 3-10 and up to 18 in east and southern African protected areas (Makacha and Schaller 1969, Schaller 1972, Rudnai 1973, Rodgers 1974, Smuts 1976, van Orsdol *et al.* 1985, H. Jachmann *in litt.* 1993). The highest known density is in Kenya's Maasai Mara National Reserve, the northern extension of the Serengeti plains ecosystem, estimated at 30/100 km^2 (H. Dublin *in litt.* 1993). Density is closely linked to seasonal prey availability (van Orsdol *et al.* 1985). Average pride home range sizes vary from 26 to 226 km^2 (van Orsdol *et al.* 1985, Viljoen 1993), and can be considerably larger—Stander (1991) reported that one pride in Etosha NP had a home range of 2,075 km^2.

Protection Status

CITES Appendix II. National legislation: hunting restricted to "problem" animals over much of its range; some trophy hunting. Hunting prohibited: Angola, Cameroon, Congo, Gabon, Ghana, Malawi, Mauritania, Niger, Nigeria, Rwanda. Hunting regulated or restricted to "problem/dangerous" animals: Benin, Botswana, Burkina Faso, Central African Republic, Ethiopia, Ivory Coast, Kenya, Mali, Mozambique, Senegal, Somalia, Sudan, Tanzania, Togo, Uganda, Zaire, Zambia, Zimbabwe. Trophy hunting permitted: Botswana, Namibia, South Africa, Tanzania, Zambia, Zimbabwe. No legal protection: Burundi, Guinea Bissau, Lesotho, Namibia, Swaziland, South Africa. No information: Burundi, Chad, Djibouti, Guinea (IUCN Environmental Law Centre 1986).

Principal Threats

Lions are generally considered serious problem animals whose existence is at odds with human settlement and cattle culture. Their scavenging behavior makes them particularly vulnerable to poisoned carcasses put out to eliminate predators (E. Abe, T. Anada, P. Chardonnet, A. Simonetta *in litt.* 1993). Where the wild ungulate prey base is migratory, stock-raiding has been reported to increase during the lean season (H. Dublin *in litt.* 1993). Problems of managing big cats in the vicinity of human settlement are discussed in Part II, Chapter 2.

Action Planning

Projects 28-32.

Serval, *Leptailurus serval* (Schreber, 1776)

Other Names

Serval, chat-tigre, lynx tacheté (French); Servalkatze (German); serval (Spanish); tierboskat (Afrikaans: South Africa); aner (Amharic: Ethiopia); amich boudrar, ouchiak zilagla (Berber: Kabylia, Algeria); njuzi (Chichewa: Malawi); onca de baga baga (Creole: Guinea-Bissau); !'hòm!a (Ju/hoan Bushman: Botswana, Namibia); gato serval, gato lagar (Portugese); tadi (Setswana: Botswana); muq shabeel, dumad xabashi, shabeel adari, shabeel yer (Somalia); mondo (KiSwahili); ingwenkala, indlozi (Xhosa, Zulu: South Africa).

Description and Behavior (Plate 2)

The serval is well-adapted to hunting small prey in long grass: its legs are slim and relatively long, and shoulder height is about 0.6 m. Its neck is also elongated, its head is small and delicate, and its ears are tall. The auditory bullae are correspondingly well-developed, making up about 22% of skull length (Skinner and Smithers 1990). Males weigh 9-18 kg (averaging 11-13 kg), and females 9-13 kg, (averaging 9.7-11 kg: Smithers 1971, Kingdon 1977, Smithers 1978). Coat color is pale yellow, and is marked with solid black spots along the sides and bars on the neck and shoulders.

Although 17 subspecies are listed by Allen (1939), their validity is doubtful (see Appendix 1). Smithers (1978) examined specimens from one locality in southern Africa and found external characters among them which had been used to designate six different subspecies within the sub-region. Servals from west Africa most frequently show a pattern mutation of small speckled spots—these so-called servalines were considered a separate species (*Felis brachyura* Wagner, 1841) until Pocock (1917a) demonstrated that the speckled form was a serval morph. Black servals have been widely recorded (Shortridge 1934, York 1973, Guggisberg 1975). The holotype of *L. serval* was taken near the Cape of Good Hope, but the serval now appears to have been extirpated from the entire southern coastal belt of South Africa and most of Cape province (Skead 1980, Stuart 1985)—although M. Bowland (*in litt.* 1993) notes an unconfirmed report from a farmer at George, midway between Cape Town and Port Elizabeth.

Small mammals, especially rodents, are the serval's main prey. Larger rodents are preferred, particularly vlei (swamp) rats (Smithers and Wilson 1979, Geertsema 1985, Bowland 1990), and Nile rats (Geertsema 1976, 1985). Smaller mice are of secondary importance (Smithers and Wilson 1979, Geertsema 1985, Bowland 1990). Up to 12 mice were found in one serval stomach from Zimbabwe (Smithers 1978). Birds, reptiles, fish, and insects are also taken, although infrequently when rodents are abundant (Geertsema 1985, Bowland 1990). Geertsema (1985) observed one young male serval, on a moonlit night, rush into open water to seize one of a group of feeding flamingos. Geertsema (1985) also found frogs to be a particularly favorite prey item, with remains occurring in 77% of 56 scats. She saw another young male eat at least 28 frogs in one three-hour period. Servals do not generally take larger prey as does the caracal. Single animals have only rarely been observed to kill duikers and fawns of the smaller antelope species (Rahm 1966, de Pienaar 1969, York 1973). The detailed studies by Geertsema (1985: Ngorongoro Conservation Area, Tanzania) and Bowland (1990: Natal province farmland, South Africa) did not record any instances of servals taking mammalian prey larger than rodents.

The serval locates prey in tall grass or reeds primarily by hearing. It makes a characteristic high leap as it pounces on a prey animal, striking it on impact to prevent escape in thick vegetation. A single pounce may span 1-4 meters and may be over a meter high (Geertsema 1985). Another type of leap is vertical: birds and insects are seized from the air by "clapping" the front paws together (Smithers 1978) or striking with a downward blow (Leyhausen 1979).

Geertsema's (1985) four-year study in the Ngorongoro Crater is the most detailed investigation to date of serval ecology. She found them to be largely crepuscular, resting in mid-day and occasionally at night. Females with kittens increase diurnal hunting activity. Servals on farmland in South Africa's Natal province were predominantly nocturnal, possibly a response to human disturbance (Bowland 1990). Through continuous observations (when possible—although the study animals were habituated, they were not radio-collared), Geertsema (1985) found that adult males, adult females and sub-adults spend about 25% of each 24-hour period travelling and hunting. On average, Ngorongoro servals killed about 16 times within this period. Independent sub-adults killed more frequently than adults, but took smaller prey with a lower energetic return. From nearly 2,000 observations of pounces, Geertsema (1985) found serval hunting success to average 49%, with no significant difference between day and moonlit night. After giving birth to kittens, one female increased her success to 62% from 48%.

Biology

Reproductive season: (W) Aseasonal, but birth peaks appear to be correlated with wet seasons, when prey densities are at their highest due to new vegetative growth (Kingdon 1977, Smithers 1978). Geertsema (1985) suggests that a peak occurs in the mid- to late dry season in the Ngorongoro Crater, so that post-rains high prey density coincides with the raising of older but still dependent kittens.

Estrus: (C) 4 days (n=1: Mellen 1989).

Gestation: (C) 73 days (n=15; range 70-79) (Stuart and Wilson 1988).

Litter size: (W) 2.5 (n=7; range 1-3) (Smithers 1978); (C) 1.96 (n=20: Skinner and Smithers 1990); 2.45 ± 0.21 (n=14: Mellen 1989); range 1-5 (Stuart and Wilson 1988).

Age at independence: (W) 6-8 months. Newly independent juveniles, tolerated by their mothers, may circulate within their natal range for periods up to and over a year (Geertsema 1985).

Age at sexual maturity: (C) 18-24 months (P. Andrews *in litt.* 1993).

Longevity: (C) up to 19 years (Green 1991).

Habitat and Distribution

In sub-Saharan Africa, servals are found in well-watered savannah long-grass environments (Shortridge 1934, Rosevear 1974, Smithers 1978), and are particularly associated with reedbeds and other riparian vegetation types (Geertsema 1985, Bowland 1990). This association with water sources means that their distribution is strongly localized over a wide area and within a variety of habitat types (Fig. 5). They range up into alpine grasslands (Ansell and Dowsett 1988), up to 3,200 m in Ethiopia (Yalden *et al.* 1980) and 3,800 m in Kenya (York 1973). Servals can penetrate dense forest along waterways and through grassy patches, but are absent from the rain forests of central Africa. A few records from arid parts of southwestern Africa, Ethiopia and Somalia indicate that servals will occasionally make use of sub-optimal habitats

(Shortridge 1934, Yalden *et al.* 1980, Stuart and Wilson 1988, A. Simonetta *in litt.* 1992).

In north Africa, relict populations may still be found in humid scrub and mixed woodlands of Morocco's Atlas Mountains (Lambert 1966) and northern Tunisia and Algeria (Gouttenoire 1954, De Smet 1989). The last confirmed record from Algeria is of an animal killed by a French hunter in 1936 in Arzew (northwest coast), said to be the last in the area. There have been scattered reports of serval occurrence throughout northern Algeria during the 1980s, but zoologists have not been able to confirm them (De Smet 1989, K. de Smet *in litt.* 1993). Surviving animals are likely to have been isolated from sub-Saharan populations for at least 6,000-7,000 years (Swift 1975).

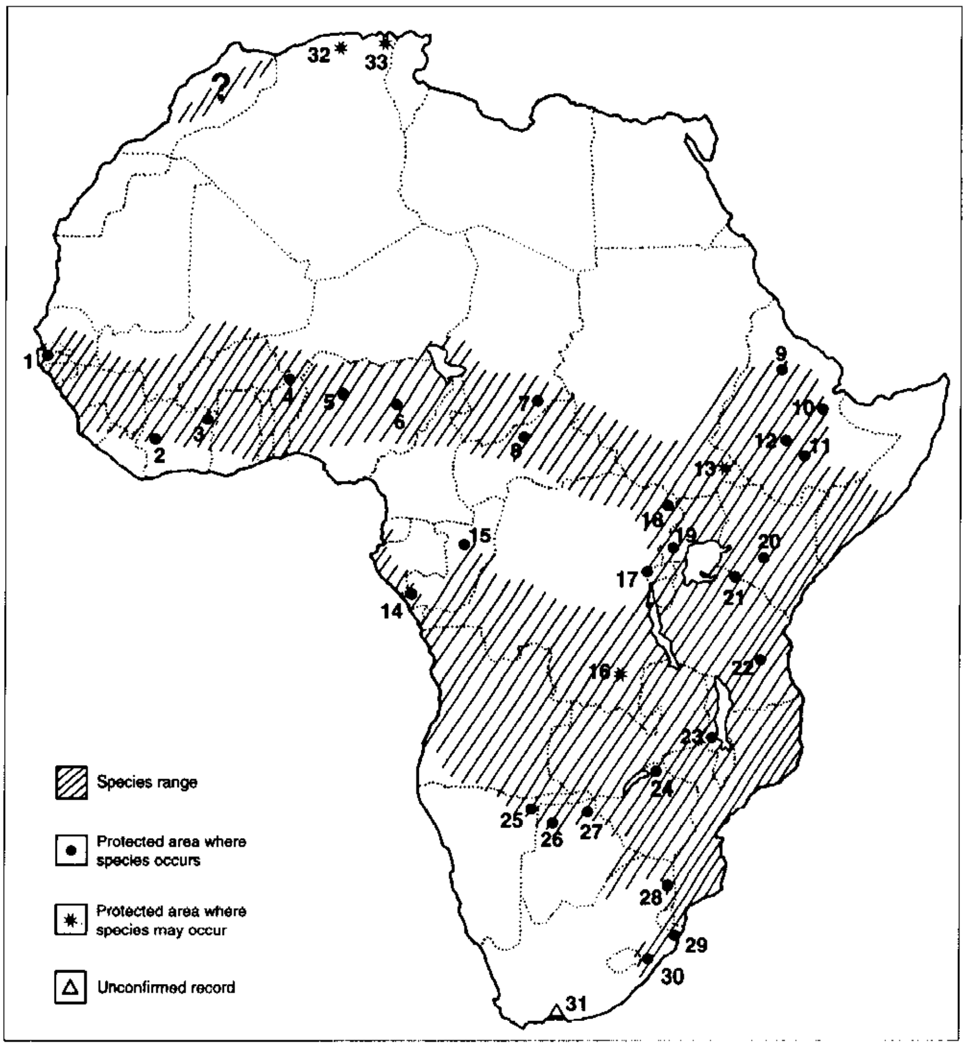

Figure 5. Distribution of the serval (*L. serval*).
1. Abuko IV (Gambia); 2. Mont Sangbe II; 3. Comoe II# (Ivory Coast); 4. "W" II* complex (Burkina Faso, Benin and Niger); 5. Kwiambana VIII complex; 6. Yankari II (Nigeria); 7. Zakouma II complex (Chad); 8. Bamingui-Bangoran II* complex (Central African Republic); 9. Simien Mts.** II; 10. Yangudi Rassa II; 11. Bale Mts II; 12. Abijatta-Shalla Lakes II (Ethiopia); 13. Boma II (Sudan); 14. Conkouati IV; 15. Odzala II* complex (Congo); 16. Upemba II; 17. Virunga II** complex; 18. Garamba II** complex (Zaire); 19. Queen Elizabeth II* complex (Uganda); 20. Aberdare II (Kenya); 21. Maasai Mara II (Kenya) + Serengeti II# (Tanzania) complex; 22. Selous IV** complex (Tanzania); 23. Kasungu II (Malawi); 24. Mana Pools II** complex (Zimbabwe); 25. Kaudom VIII (Namibia); 26. Moremi IV; 27. Chobe II (Botswana); 28. Kruger II complex; 29. St. Lucia IV complex; 30. Natal Drakensberg IV; 31. unconfirmed observation of a serval by a farmer near George, Cape province, South Africa (M. Bowland *in litt.* 1993); 32. Djurdjura II; 33. El Kala V* (Algeria: De Smet 1989).

Population Status

Global: Category 4. Regional (sub-Saharan Africa): Category 3. Regional (north Africa): Category 2(A). IUCN: not listed. Smithers (1978) reviewed the serval's distribution and concluded that its range has remained largely intact, shrinking only in the extreme north and south due to habitat loss in the wake of increasing urbanization and changes in land use (C. Stuart *in litt.* 1993). Possibly servals were never very numerous in north Africa, and water sources in the region are likely to be focal points of human use and settlement. However, servals are highly tolerant of agricultural development, which fosters increased rodent densities, as long as there is sufficient water and shelter available (Bowland 1990). Kingdon (1977) notes that the serval has adapted well to the cultivation-fallow mosaic that is widespread over the moister regions of Africa. Degradation of forests to savannah in west Africa probably favors the species.

Geertsema (1985) found minimum home ranges in Ngorongoro to be 11.6 km^2 for one adult male and 9.5 km^2 for one adult female over four years. The male's home range overlapped those of at least two adult females, while the ranges of three adult females showed minimal overlap. Bowland (1990) found larger home ranges for servals on South African ranchland: 16-20 km^2 for two adult females and 31.5 km^2 for one male, monitored for 4-5 months during the spring and summer.

Protection Status

CITES Appendix II. National legislation: not protected over most of its range. Hunting prohibited: Algeria, Botswana, Congo, Kenya, Liberia, Mozambique, Nigeria, Rwanda, South Africa (Cape province only). Hunting regulated: Angola, Burkina Faso, Central African Republic, Ghana, Malawi, Senegal, Sierra Leone, Somalia, Tanzania, Togo, Zaire, Zambia. No legal protection: Benin, Cameroon, Ethiopia, Gabon, Gambia, Guinea Bissau, Ivory Coast, Lesotho, Malawi, Mauritania, Morocco, Namibia, Niger, South Africa, Sudan, Swaziland, Tunisia, Uganda, Zimbabwe. No information: Burundi, Chad, Djibouti, Guinea (IUCN Environmental Law Centre 1986, Smithers 1986, Hecketsweiler 1988).

Principal Threats

Wetland conservation is the key to serval conservation. Wetlands harbor comparatively high rodent densities compared to other habitat types, and form the core areas of serval home ranges (Geertsema 1985, Bowland 1990). Of secondary importance is degradation of grasslands through annual burning followed by over-grazing by domestic hoofstock, leading to reduced abundance of small mammals (F. Hurst *in litt.* 1991, Rowe-Rowe 1992).

Trade in serval pelts has been reported from many countries (Yalden *et al.* 1980, Sayer and Green 1984, Myers 1986, Cunningham and Zondi 1991; L. Gadsby, F. Hurst *in litt.* 1991, E. Abe *in litt.* 1993); they are frequently marketed as "cheetah" or "leopard." While the scale of the harvest and its effect upon populations is difficult to judge, the pelt trade appears to be primarily domestic (especially for ceremonial or medicinal purposes) or tourist-oriented, rather than international commercial exports (WCMC unpubl. data; see Table 1 in Part II Chapter 4). The serval's localized distribution around water sources may increase its vulnerability to hunting; it will also climb a tree when chased by hounds (Stuart 1985).

Servals occasionally kill domestic poultry and only rarely young livestock (sheep and goats): studies of their diet in farming areas in Zimbabwe (Smithers 1978) and South Africa (Lawson 1987) found no evidence that predation was a problem. Bowland (1990) pointed out that problem animals which raid chicken coops can be easily live trapped for translocation. Although 17% of Namibian farmers who indicated that servals were present on their land reported livestock predation, none took any control measures (legally permissible), indicating that the problem is not serious. For comparison, 36% of the farmers reporting stock predation by African wildcats took control measures (Joubert *et al.* 1982). The serval's preference for rodent prey should actually benefit farmers: Geertsema (1985) calculated that an adult serval will eat some 4,000 rodents a year.

Action Planning

Project 38.

Leopard, *Panthera pardus* (Linnaeus, 1758)

Other Names

Panther (English); léopard, panthère (French); Leopard, Panther (German); leopardo, pantera (Spanish); nebr (Amharic: Ethiopia); eduka, ekun, ogidan (Ibo, Yoruba: Nigeria); !'hòm (Ju/hoan Bushman: Botswana, Namibia); ngoye, nze, goye (Kota, Fang, Kwele: Gabon); damissa (Hausa: west Africa); chui (Kiswahili); kwach (Luo: Kenya, Uganda); oluwaru keri (Maasai: Kenya, Tanzania); loli, mabiti, kweyi, mabilanga, moli, ka'u (Mbuti Pygmy dialects: Zaire); nkewe, sinkwe z inqwe (Setswana: Botswana); shabeel (Somalia).

Description and Behavior (Plate 1)

The leopard has the widest distribution of the wild cats, and shows great variation in appearance and behavior. In general, the coat color varies from pale yellow to deep gold or tawny, and is patterned with black rosettes. The head, lower limbs and belly are spotted with solid black. Coat color and patterning are broadly associated with habitat type. Pocock (1932a) found the following trends in coloration for leopards in Africa: (1) savannah leopards—rufous to ochraceous in color; (2) desert leopards—pale cream to yellow-brown in color, with those from cooler regions being more grey; (3) rain forest leopards—dark, deep gold in color; (4) high mountain leopards—even darker in color than 3. Black leopards (the so-called "black panthers") occur most frequently in humid forest habitats (Kingdon 1977), but are merely a color variation, not a subspecies. Variation in pelage has been the chief basis for the description of numerous subspecies of leopard, 24 in sub-Saharan Africa alone (Smithers 1975). However, Miththapala (1992), using molecular analysis and cranial measurements, concluded that sub-Saharan African leopards showed too little difference to warrant subspecific division and proposed that the 10 sub-Saharan subspecies she examined should be subsumed into *P.p. pardus*, the name originally applied to the north African leopard.

The leopard is well known for its versatility as a generalist predator, and shows a number of morphological adaptations to this end, including its size, which shows wide variation across its range. Exceptionally large males weighing over 91 kg have been reported from South Africa's Kruger National Park (Turnbull-Kemp 1967), where average adult weights are otherwise 58 kg for males (n=3) and 37.5 kg for females (n=5: Bailey 1993). Male leopards from the coastal mountains of South Africa's Cape Province are much smaller, with an average weight of 31 kg (n=27: Stuart 1981). Norton (1984) suggests that this is because prey species are smaller in these mountains. In the rain forests of northeastern Gabon, one adult female weighed 26 kg, and two males weighed 34 and 41 kg (S. Lahm *in litt.* 1993). In the rain forest of the Ivory Coast's Taï National Park, on the other hand, a male leopard was captured which weighed 56 kg (Jenny 1993), and two females weighed 32 kg and 33 kg (Jenny *in litt.* 1994).

Despite its relatively small body size, the leopard is still capable of taking large prey. Its skull is massive, giving ample room for attachment of powerful jaw muscles. Its whiskers are particularly long and there are often several extra long hairs in the eyebrows, protecting the eyes and assisting movement through vegetation in darkness (Skinner and Smithers 1990). Its scapula is adapted for the attachment of powerful muscles that raise the thorax, enhancing its ability to climb trees (Hopwood 1947). Leopards can live independent of water for periods of time, obtaining moisture requirements from prey (Bothma and Le Riche 1986).

The known prey of the leopard ranges from dung beetles (Fey 1964) to adult male eland (Kingdon 1977), which can reach 900 kg (Stuart and Stuart 1992a). Bailey (1993) found that at least 92 prey species have been documented in the leopard's diet in sub-Saharan Africa. The flexibility of the diet is illustrated by Hamilton's (1976) analysis of leopard scats from Kenya's Tsavo West National Park, of which 35% contained rodents, 27% birds, 27% small antelopes, 12% large antelopes, 10% hyraxes and hares, and 18% arthropods. Seidensticker (1991a) and Bailey (1993) reviewed the literature, and concluded that leopards generally focus their hunting activity on locally abundant medium-sized ungulate species in the 20-80 kg range, while opportunistically taking other prey. For example, analysis of leopard scats from a Kruger NP study area found that 67% contained ungulate remains, of which 60% were impala, the most abundant antelope, with adult weights of 40-60 kg. Small mammal remains were found most often in scats of sub-adult leopards, especially females (Bailey 1993). Studies have found average intervals between ungulate kills to range from seven (Bailey 1993) to 12-13 days (Hamilton 1976, Le Roux and Skinner 1989). Bailey (1993) estimated average daily consumption rates at 3.5 kg for adult males and 2.8 kg for females.

However, the leopard has an exceptional ability to adapt to changes in prey availability, and has a very broad diet. Small prey are taken where large ungulates are less common. For example, Grobler and Wilson (1972) and Norton *et al.* (1986) analyzed leopard scats taken from Zimbabwe's Matopos National Park and the mountains of southwestern Cape province and found rock hyraxes, common in the study areas, to be the most frequently taken prey. In central African rain forest, both Jenny (1993) and J. Hart and M. Katembo (in prep.) found the diet to consist mainly of duikers and small primates. Jenny (1993) notes also that some individual leopards have shown a strong preference for pangolins and porcupines. In his study area, the Ivory Coast's Taï National Park, a long-term study of chimpanzees determined leopard predation to be the major cause of chimp mortality (Boesch 1991), but D. Jenny (*in litt.* 1994) believes this may have been the work of a specialist chimp-killing leopard. In the interior areas of South Africa's Kalahari Gemsbok National Park, where springbok are less abundant, Bothma and Le Riche (1984) found that 80% of leopard kills located by tracking (n=30) weighed less than 20 kg; nevertheless, 37% of all kills consisted of ungulates. By using the tracking method, they found that male leopards killed every three days on average, and females with cubs every 1.5 days. At 3,900 m in the Kilimanjaro Mountains of Tanzania, Child (1965) reported the leopard's diet to consist mainly of rodents, while Fey (1964) describes how a leopard stranded on an island in the wake of Kariba Dam subsisted primarily on fish (*Tilapia*), even though impala and common duiker were present in low numbers.

The leopard shows several behavioral adaptations which permit it to compete successfully with other large predators, the first being its dietary flexibility. Bertram

(1982) studied radio-collared lions and leopards in the same area in the northern Serengeti and found that, while their ranges overlapped, leopards preyed on a wider range of animals than did lions, and there was little overlap between their diets. Secondly, leopards often cache large kills in trees. Great strength is required: there have been several observations of leopards hauling carcasses of young giraffe, estimated to weigh up to 125 kg (2-3 times the weight of the leopard) up to 5.7 m into trees (Hamilton 1976, Scheepers and Gilchrist 1991). This behavior is more common in areas where competing carnivores are numerous (Schaller 1972, Bothma and Le Riche 1984); where they are not, leopards may still drag the carcasses of large prey some hundreds of meters from the kill site into dense vegetation or a rock crevice (Smith 1977). Leopards may also retreat up a tree in the face of direct aggression from other large carnivores. In addition, leopards have been seen to either kill or prey on small competitors, e.g. black-backed jackal (Estes 1967), African wild cat (Mills 1990) and the cubs of large competitors (lion, cheetah, hyenas, wild dogs: Bertram 1982). Leopards have also been observed to ambush terrestrial prey by leaping down from tree branches, although this behavior is apparently opportunistic and relatively uncommon (Kruuk and Turner 1967); like other cats, they probably generally prefer to get their footing on the ground before launching the actual attack (Leyhausen 1979). While the diet of rain forest leopards may include arboreal animals (40% of scats from Taï NP contained arboreal species, including seven species of primate: Hoppe-Dominik 1984), they are unlikely to forage much in trees: radio-collared leopards in Taï have only been observed to attack monkeys when on the ground (D. Jenny *in litt.* 1994).

Leopards are generally most active between sunset and sunrise, and kill more prey at this time (Hamilton 1976, Bailey 1993). In Kruger NP, Bailey (1993) found that male leopards and female leopards with cubs were relatively more active at night than solitary females. The highest rates of daytime activity were recorded for leopards using thorn thickets during the wet season, when impala also used them (Bailey 1993). In tropical rain forest, D. Jenny *in litt.* (1994) reports that two radio-collared leopards (an adult male and female) have hunted only during the day, although they often travel at night.

Biology

Reproductive season: (W) probably year-round, but Bailey (1993) found a peak in leopard births during the birth season of impala, the main prey species.

Estrus: (C) average 7 days.

Estrus cycle: (C) average 46 days (Sadleir 1966).

Gestation: (C) 96 (90-105) days (Hemmer 1976).

Litter size: (C) 1.65 (range 1-4; n=59) (Eaton 1977); (W) (according to time of first observation, when cubs may be several weeks old and some may have died) 2.13 (range 2-3; n=16) (Martin and de Meulenaer 1988).

Cub survival: (W) first-year mortality estimated at 41% (Martin and de Meulenaer 1988) to at least 50% annually (Bailey 1993).

Sub-adult survival: (W) Average annual mortality of sub-adults (1.5-3.5 years old) was estimated in Kruger NP at 32%, nearly twice as high as adults, probably related to poorer hunting success. Females: 40%; males: 25% (Bailey 1993).

Interbirth interval: (W) average 15 months (Martin and de Meulenaer 1988; these data include some shorter periods after litters did not survive) to over 2 years (Schaller 1972, Bailey 1993).

Age at independence: (W) 13-18 months (Bailey 1993, Skinner and Smithers 1990). Siblings may remain together for several months before separating (Skinner and Smithers 1990). Dispersal may be delayed in areas where prey are abundant, especially if adjacent habitat is occupied by resident leopards (Bailey 1993).

Age at first reproduction: females: (C) 33 months (range 30-36: Weiss 1952), (W) average 35 months (n=8: Martin and de Meulenaer 1988); males: 2-3 years (C: Green 1991).

Reproductive rate: (W) Bailey (1993) reported that the average proportion of adult females producing young each year in his Kruger NP study area was 28%, while noting that in some years no females gave birth, while in others up to half of the females produced young.

Sex ratio of resident adults: (W) 1 male:1.8 females (Bailey 1993, Hamilton 1981).

Age at last reproduction: (C) average 8.5 years at one zoo (females: Eaton 1977), but up to 19 years (both sexes: A. Shoemaker *in litt.* 1993).

Adult mortality: (W) average 19% annual mortality for adult leopards in Kruger National Park. Old males 30%; prime males 17%; old females 17%; prime females 10%. The proportion attributable to starvation was 64% (Bailey 1993).

Longevity: (W) probably 10-15 years (Turnbull-Kemp 1967, Martin and de Meulenaer 1988); (C) generally 12-15 years, but up to 20 (A. Shoemaker *in litt.* 1993).

Habitat and Distribution

Leopards occur in most of sub-Saharan Africa. They are found in all habitats with annual rainfall above 50 mm

(Monod 1965), and can penetrate areas with less than this amount of rainfall along river courses: e.g.leopards are found along the Orange River in the Richtersveld National Park (South Africa), which lies at the southernmost extension of the Namib Desert (Stuart and Stuart 1989). Out of all the African cats, the leopard is the only species which occupies both rain forest and arid desert habitats. Leopards range exceptionally up to 5,700 m, where a carcass was discovered on the rim of Mt. Kilimanjaro's Kibo Crater in 1926 (Guggisberg 1975). They are abundant on the highest slopes of the Ruwenzori and Virunga volcanoes, and have been observed to drink thermal water (37° C) in Zaire's

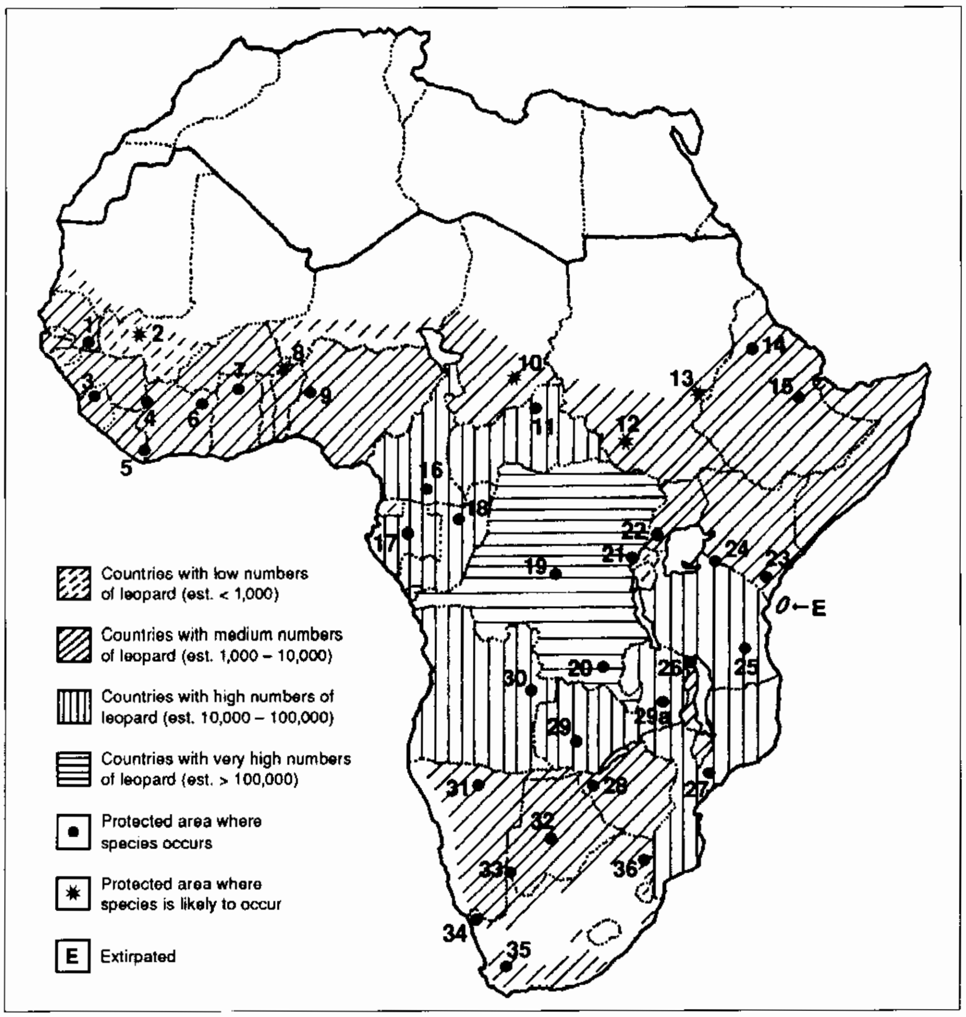

Figure 6. Distribution and relative abundance of the leopard (*P. pardus*) in sub-Saharan Africa (after Martin and de Meulenaer 1988).
1. Niokolo-Koba II# (Senegal); 2. Boucle du Baoule II complex (Mali); 3. Outamba-Kilimi IV (Sierra Leone); 4. Mt. Nimba I# complex (Guinea and Ivory Coast); 5. Sapo II (Liberia) + Taï II# (Ivory Coast) complex; 6. Comoe II# (Ivory Coast); 7. Mole II (Ghana); 8. "W" II* complex (Burkina Faso, Benin and Niger); 9. Kainji Lake II (Nigeria); 10. Zakouma II complex (Chad); 11. Manovo-Gounda-St. Floris II** (Central African Republic); 12. Southern II; 13. Dinder II* complex (Sudan); 14. Simien Mts. II**; 15. Yangudi Rassa II (Ethiopia); 16. Dja IV# (Cameroon); 17. Lope IV (Gabon); 18. Odzala II* complex (Congo); 19. Salonga II**; 20. Upemba II; 21. Virunga II** complex (Zaire); 22. Mt. Ruwenzori II* complex (Uganda); 23. Tsavo II complex (Kenya); 24. Maasai Mara II (Kenya) + Serengeti II# complex (Tanzania); 25. Selous IV** complex (Tanzania); 26. Nyika II (Malawi); 27. Zambezi Wildlife Utilization Area (Mozambique); 28. Hwange II complex (Zimbabwe); 29. Kafue II complex; 29a. S. Luangwa II Complex (Zambia); 30. Kameia VI (Angola); 31. Etosha II (Namibia); 32. Central Kgalagadi II complex (Botswana); 33. Gemsbok II (Botswana) + Kalahari Gemsbok II (South Africa) complex; 34. Richtersveld V; 35. Cedarsburg IV; 36. Kruger II complex (South Africa).

Virunga National Park (J. Verschuren *in litt.* 1993).

The leopard appears to be very succesful at adapting to altered natural habitat and settled environments in the absence of intense persecution. There are many records of their presence near major cities (e.g.Turnbull-Kemp 1967, Guggisberg 1975, Tello 1986a, Martin and de Meulenaer 1988: 18; G. Davies, B. Hoppe-Dominik, R. Kock, P. Norton *in litt.* 1993). Hamilton (1986b) reports their occurrence in western Kenya in extensively cultivated districts with more than 150 persons/km^2, the largest livestock populations in the country, little natural habitat and prey, and where 20 years ago they had been considered extirpated.

However, leopards appear to have become rare throughout much of west Africa (Martin and de Meulenaer 1988: 11-14). According to T. Anada (*in litt.* 1993), they have completely disappeared from much of the western Sahel.

Figure 6 shows the distribution of the leopard. Countries are coded for abundance as determined by Martin and de Meulenaer (1988) (see explanation below), except that equatorial Guinea, Mali, Nigeria, and Zimbabwe have been down-graded one category.

Population Status

Global: Category 5a(A). Regional: Category 4(A). IUCN: not listed. The status of the leopard in sub-Saharan Africa has been a matter of controversy since 1973, when it was first listed on CITES Appendix I due to fear about the impact of the then considerable international trade in leopard skins (Myers 1973). Six attempts have since been made to determine the leopard's status (Myers 1976, Teer and Swank 1977, Eaton 1978, Hamilton 1981, Martin and de Meulenaer 1988, Shoemaker 1991). The first four relied mainly on interviews and questionaires, but Hamilton's (1981) work was more intensive, supplemented by the author's own field studies, and focused wholly on Kenya as a microcosm of the forces impacting leopard populations throughout the continent. Martin and de Meulenaer (1988) also carried out wide-ranging interviews, but carried the process one step further by developing a population model for the leopard, which they used in combination with a regression linking leopard densities with annual rainfall to predict numbers of leopard in the region. More recently, Shoemaker (1991) conducted an extensive literature review and global correspondence to summarize the status of the leopard throughout its entire world range.

The first five studies were criticized from different viewpoints (e.g.Hamilton 1981: 93-94, USFWS 1982, Martin and de Meulenaer 1988: xv-xx, Jackson 1989, Norton 1990), with the debate focusing chiefly on the accuracy of various population estimates; the model's failure to account adequately for persecution and reduction of wild prey as factors lowering leopard density; the universality of the correlation of leopard density and rainfall; and the desirability or not of re-opening commercial trade in leopard skins. R. Martin (*in litt.* 1994) concedes that a variable representing prey density should be incorporated into the regression linking leopard density to rainfall. Bailey (1993) also argues that while the link between herbivore density and rainfall may be generally valid, a herbivore biomass increase does not necessarily equate to increased leopard prey biomass. The herbivore biomass could be in the form of very large species (elephant, buffalo, hippopotamus) or herd-forming species (zebra and wildebeest), which provide little food for leopards.

Despite the controversy, there appears to be general agreement that the leopard is not currently endangered in sub-Saharan Africa, but that it is subject to local depletion through exploitation and loss of habitat. Overall, Martin and de Meulenaer (1988) estimated the sub-Saharan population to number 714,000, based on their density/rainfall regression. Although this figure is generally considered to be an overestimate (Jackson 1989, Norton 1990), it represents the most practical and quantitative attempt to date to estimate potential cat numbers across a large geographic area. Its accuracy should be tested and improved by continuing investigation into leopard densities in key habitats, including tropical rain forest.

Biologists working in central African rain forest all describe the leopard as common (M. Agnanga, R. Barnes, A. Blom, J. Hart, S. Lahm *in litt.* 1993). The rainfall/density regression used by Martin and de Meulenaer (1988) suggest that Zaire would hold some 33% of sub-Saharan African leopards, a figure resulting from presumed very high densities in tropical rain forest (up to 40 leopards, including young and transients, per 100 km^2). However, Bailey (1993) is among several authorities who have argued that since terrestrial mammalian prey biomass is lower in rain forest than in savannah environments, as the bulk of productivity is locked up in the tree canopy, therefore leopard density should be correspondingly lower.

Two studies are currently underway which should eventually yield the first good data on leopard abundance in this habitat type (J. Hart, D. Jenny in prep.). D. Jenny (*in litt.* 1994) provides a preliminary estimate of five adult leopards in his 80 km^2 study area in Taï NP, or 6.25 leopards per 100 km^2. J. Hart (*in litt.* 1994) offers a preliminary estimate of one adult leopard per 8-12 km^2 in Zaire's Ituri forest, or 8.3-12.5 leopards per 100 km^2. These estimates are considerably lower than the 40 leopards per 100 km^2 suggested by Martin and de Meulenaer's rainfall/density regression. Yet they are also higher than adult leopard densities estimated for the Seronera woodland area of Tanzania's Serengeti NP (3.5 [Schaller 1972] - 4.7 [Cavallo 1993] per 100 km^2), which are among the greater densities on the rainfall/density regression if the rain forest estimates are excluded. In South Africa's Kruger NP, Bailey (1993) estimated average leopard density at 3.5 adults per 100 km^2, with much higher densities of up to 30.3 per 100 km^2 in the riparian forest zones, with high prey density. Leopard densities are lowest in arid environments (Martin and de Meulenaer 1988): for example, 1.25 adults per 100 km^2 in South Africa's Kalahari Gemsbok NP (Martin and de Meulenaer 1988, based on Bothma and Le Riche 1984). Hamilton (1981) and Cavallo (1993) found that multiplying the number of adult residents by 1.7 accurately accounted for the total number of known animals in their study areas.

Leopards appear to be least numerous in west Africa, possibly due to high levels of hunting for their skins, and depletion of prey due to the trade in bushmeat (Myers 1976, Martin and de Meulenaer 1988). T. Anada (*in litt.* 1993) considers the leopard to be more rare than the lion in the savannah regions, while severely reduced abundance was also reported from the west African rain forest zone (Martin and de Meulenaer 1988). Also, in South Africa, the leopard has been extirpated from many areas (Stuart *et al.* 1985, Norton 1986, Rowe-Rowe 1992).

Leopard home range sizes determined by radiotelemetry have averaged between 30-78 km^2 (males) and 15-16 km^2 (females) in protected areas (Tsavo NP: Hamilton 1981; Kruger NP: Bailey 1993; Serengeti NP: Bertram 1982; Cedarberg Wilderness Area [South Africa]: Norton and Henley 1987). Long-term observations of individual female leopards have yielded larger estimates of home range size in protected areas: 23-33 km^2 (Le Roux and Skinner 1989) and 37-38 km^2 (Cavallo 1993). Bailey (1993) found the ranges of adult females were centered on the most prey-rich habitat (riparian vegetation), while the larger male ranges included lower quality habitat. In mountainous terrain interspersed with farms and ranches, Norton and Lawson (1985) found leopard home ranges of 338-487 km^2 (for a male and female, respectively), suggesting both severely reduced prey availability and low leopard density. On a Kenyan cattle ranch which maintained wild ungulates, Mizutani (1993) found female leopard home ranges to average 18 km^2 (n=4) and males 55 km^2 (n=4). In the Taï rain forest in Ivory Coast, Jenny (*in litt.* 1994) reported a male range of 80 km^2 and a female range of 25 km^2.

Protection Status

CITES Appendix I. A system has been in place since 1983 by which selected African countries accept an annual quota for the export of legitimate sport hunting trophies and skins. As of 1994, the quotas are as follows: Botswana (130), Central African Republic (40), Ethiopia (500), Kenya (80), Malawi (50), Namibia (100), Mozambique (60), South Africa (75), Tanzania (250), Zambia (300), Zimbabwe (500). National legislation: largely protected across its range, although killing of "problem" animals, either by landowners or government authorities, generally permitted. Hunting prohibited or restricted to "problem/dangerous" animals: Angola, Benin, Burkina Faso, Cameroon, Congo, Djibouti, Equatorial Guinea, Gabon, Ghana, Guinea Bissau, Ivory Coast, Liberia, Mali, Mauritania, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, Somalia, Sudan, Togo, Uganda, Zaire. No legal protection: Gambia. No information: Burundi, Chad, Guinea (IUCN Environmental Law Centre 1986, Shoemaker 1993).

Principal Threats

Although the leopard appears tolerant of habitat modification and occurs in the vicinity of settled areas, density is certainly reduced when compared to occurrence in natural habitat (perhaps as low as 1/10 or even 1/100, as estimated by Martin and de Meulenaer [1988]), and the leopard becomes more vulnerable to exploitation and population fragmentation.

The fur trade was a major threat to the leopard in some areas during the 1960s and 1970s, before the market collapsed due to changing public opinion and the imposition of international trade controls under CITES (see Part II Chapter 4). Hamilton (1981) reported that poaching for the fur trade substantially reduced the leopard population in Kenya, and considers the species to be particularly vulnerable to baited trapping, as leopards patrol small home ranges along regularly used trails. Use of poisoned baits is also an important threat (Myers 1976; E. Abe, T. Anada, P. Chardonnet, A. Simonetta *in litt.* 1993). Martin and de Meulenaer (1988) simulated the effects of high harvests on leopards in east Africa during this period (they estimated 30,000 leopards killed between 1968-69), and concurred with Hamilton's (1981) finding that hunting had severely depressed populations there. However, their model also indicated that even very high offtakes, of the order of 61,000 animals a year, had produced only a slight decline in the total sub-Saharan population (see Part II Chapter 5). They consider the leopard to be generally resilient to harvest up to a critical threshold, which varies with density.

Martin and de Meulenaer (1988) argue that re-opening the fur trade with appropriate controls under CITES would significantly benefit conservation of the leopard by allowing local people to derive economic value from the species, seldom possible under current tourism and sport hunting practices of most range states. Rural people are at present the force responsible for the continuing decline of the leopard in the region, through degradation of habitat where their livestock graze and persecution of the leopard as a threat to these animals. Development of options to enable local people to obtain income from leopards could encourage them to refrain from eradicating the leopards in their vicinity. Cobb (1981), without considering such options, could not foresee a future for the leopard in Africa outside of protected areas. In 1986, protected habitat made up only 13% of potential leopard range (MacKinnon and MacKinnon 1986a, Martin and de Meulenaer 1988).

Action Planning

Projects 33 and 34.

Caracal, *Caracal caracal* (Schreber, 1776)

Other Names

Desert lynx (English); caracal (French); caracal, Wüstenluchs (German); caracal, lince africano (Spanish); rooikat, lynx (Afrikaans: South Africa); delg ambassa (Amharic: Ethiopia); djimé taikorlo (Baguirmien); soumoli (Bornouan); guétté anasa (Chad); filiki (Djerma); pyabéri (Gourmanché: Burkina Faso); messo (Hausa: Sahel); !hab (Hei//kum Bushman: Namibia); simbamangu (Kiswahili); =ui (Ju/'hoan Bushman: Botswana, Namibia); mwai (Luo: Kenya, Uganda); indabutshe, intwane (Ndebele: Zimbabwe); ayuku (Ovambo: Namibia); safandu (Peul/Foulbé); thwane (Setswana: Botswana); hwang, twana (Shona: Zimbabwe); gedudene, maharra (Somalia); daga (Toucouleur: northwest Africa); ngada (Xhosa: South Africa).

Description and Behavior (Plate 3)

A distinctive feature of the caracal is the black back of its large ears (its name comes from the Turkish "karakulak" or "black ear"). The ears are topped with black tufts about 4.5 cm in length (hence the other popular name, lynx, although the caracal is not closely related to the lynxes). The conspicuous ears are believed to play a role in intraspecific communication (Kingdon 1977). Caracals are generally uniformly tawny-brown to brick-red in coloration, although black individuals have been recorded (Rosevear 1974, Guggisberg 1975). Caracals are the largest of the African small cats: males can weigh up to 18 kg (average 13 kg, Cape Province, South Africa; n=61) and females up to 16 kg (average 10 kg in Cape Province; n=41) (Stuart 1981).

Caracals prey on a variety of mammals, with rodents, hares, hyraxes and small antelopes forming the major part of their diet (Smithers 1971, Grobler 1981, Stuart 1982, Moolman 1986, Palmer and Fairall 1988) in many areas. In South Africa's West Coast National Park, near Cape Town, Avenant (1993) found that rodents were the most common prey remains found in caracal scats, occurring with 89% frequency. Antelope remains were more common than rodents in 194 stomachs collected from individuals killed as problem animals in Cape Province (Stuart 1981). Caracals are capable of taking relatively large prey: successful predation on adult springbok (Avenant 1993) and young kudu (Shortridge 1934) has been reported.

After making a kill, caracals have been reported, leopard-like, to cache the remains in a tree (Roberts 1951, Mills *et al.* 1984), although this behavior is apparently not common. Caracals have rarely been recorded to take carrion (Skinner 1979, C. Stuart *in litt.* 1991). However, in Namibia's Etosha National Park, a young adult female scavenged from a springbok killed by a cheetah, waiting for two hours for the cheetah to finish eating and move off (B. Bjil and K. Nowell pers. obs.). Moolman (1984a) successfully captured caracals for his study in the Mountain Zebra National Park, South Africa, by placing box traps near half-eaten large prey (mountain reedbuck) originally caught by a caracal, to which the animal eventually returned to feed. Shortridge (1934) states that they are fairly easy to trap, as long as the bait is fresh. A female with cubs was observed to return to feed on her springbok carcass for 3-4 consecutive nights (Avenant 1993). Caracals are also known for their exceptional ability to catch birds, leaping high into the air to knock them down with their front paws. Avenant (1993) found that bird remains occurred in 18% of caracal scats in the West Coast NP, while Moolman (1984b) found their occurrence in only 2-4% of scats collected in and around the Mountain Zebra NP. Invertebrates and reptiles are also eaten. Mean daily food intake for captive adult caracals has been estimated by Moolman (1986) at 500 g for males and 316 g for females. Caracals are predominantly nocturnal, but are often observed in the daytime, particularly in protected areas.

Biology

Reproductive season: (W) probably year-round (Bernard and Stuart 1987, Avenant 1993).

Estrus: (C) 1-3 days.

Length of estrus cycle: (C) 14 days (n=15).

Gestation: (C) 78-81 days (Bernard and Stuart 1987, P. Andrews *in litt.* 1993).

Litter size: (C) 2.2 (range 1-4; n=15); (W) wild pregnant females were also found to carry an average of 2.2 fetuses (range 1-3; n=22) (Bernard and Stuart 1987). The size of four litters in the West Coast NP also averaged 2.25 (range 1-3: Avenant 1993).

Age at first reproduction: (C) 12.5-15 months (males) and 14-16 months (females); gametogenesis can occur somewhat earlier (Bernard and Stuart 1987, P. Andrews *in litt.* 1993).

Interbirth interval: (W) probably one litter annually (Bernard and Stuart 1987).

Age at last reproduction: (C) one female gave birth at 18 years.

Longevity: (C) up to 19 years (P. Andrews *in litt.* 1993).

Habitat and Distribution

Caracals inhabit the drier savannah and woodland regions of sub-Saharan Africa, with a strong preference for the more scrubby, arid habitats (Kingdon 1977, Yalden *et al.* 1980, Stuart 1984) (Fig. 7). They are not found in the tropical rain forests (Rosevear 1974). In South Africa, where they are relatively abundant, they have been recorded (unusually) from the evergreen and montane forests of the southern Cape province (Stuart and Wilson 1988). In Ethiopia, caracals range up to 2,500 m (and exceptionally up to 3,300 m) in the Bale and Simien Mountains (Yalden

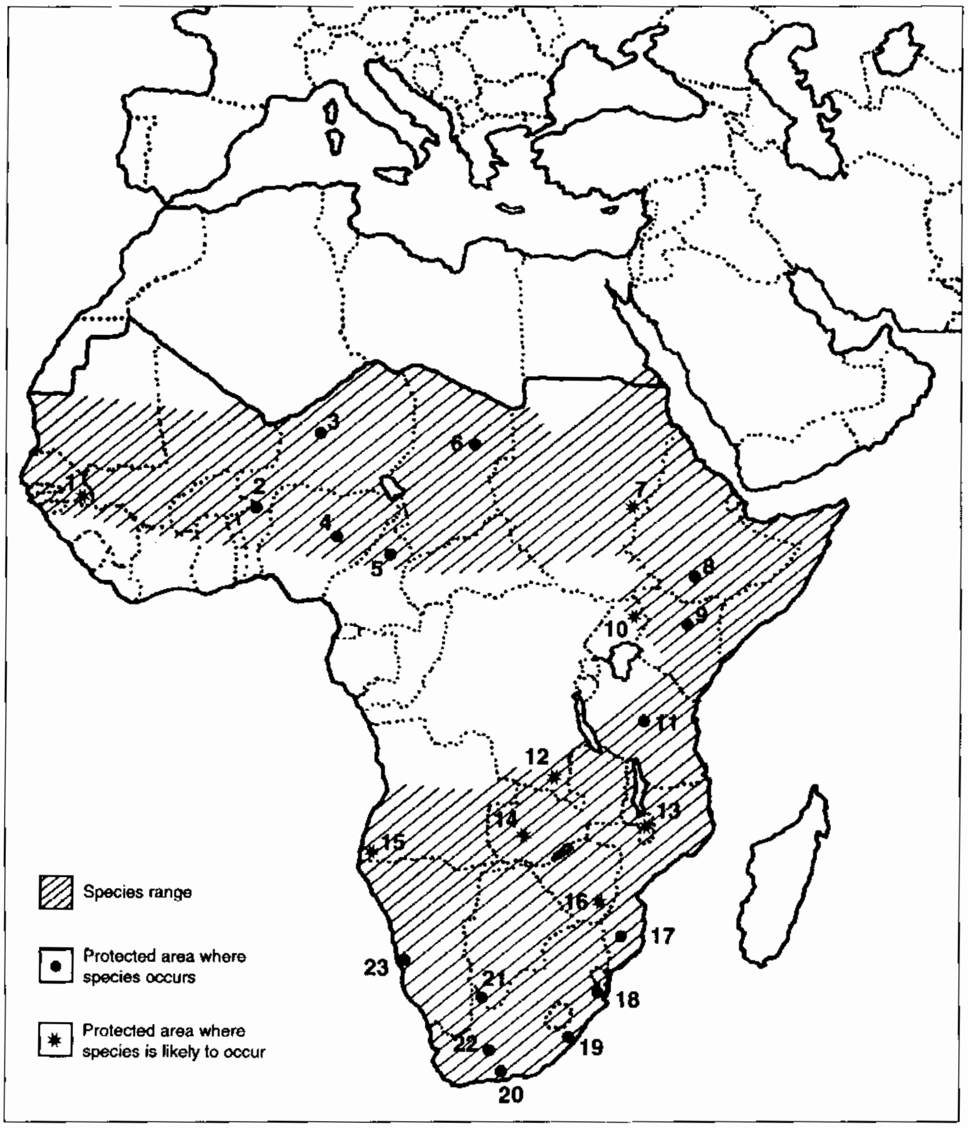

Figure 7. Distribution of the caracal (*C. caracal*) in sub-Saharan Africa.
1. Niokola-Koba II# (Senegal); 2. Boucle de la Pendjari II* complex (Benin) + "W" II* complex (Benin, Burkina Faso and Niger); 3. Aïr and Ténéré VIII (Niger); 4. Yankari II (Nigeria); 5. Benoue II* (Cameroon); 6. Fada Archei Faunal Reserve (Chad); 7. Dinder II* (Sudan); 8. Nechisar II (Ethiopia); 9. Marsabit II (Kenya); 10. Karamoja N and S VI complex (Uganda); 11. Ruaha II complex (Tanzania); 12. Kundelungu II complex (Zaire); 13. Lengwe II (Malawi); 14. Kafue II complex (Zambia); 15. Iona VI (Angola); 16. Gonarezhou II (Zimbabwe); 17. Banhine NP (Mozambique); 18. Itala IV; 19. Weza IV; 20. Storms River IV; 21. Kalahari Gemsbok II (South Africa) + Gemsbok II (Botswana) complex; 22. Karoo II (South Africa); 23. Namib-Naukluft II (Namibia).

et al. 1980).

Field studies have been carried out only in South Africa and Israel (for the latter, see species account under *North Africa and Southwest Asia*). In South Africa, adult male home range sizes in various study sites in Cape Province have ranged from 31-65 km^2, and females from 4-31 km^2 (Stuart 1982, Norton and Lawson 1985, Moolman 1986, Avenant 1993).

Population Status

Global: Category 5b. Regional: Category 4. IUCN: not listed. The status of the caracal is satisfactory in sub-Saharan Africa. It appears to be most abundant in South Africa and Namibia, where its range is expanding (Stuart and Wilson 1988, Rowe-Rowe 1992), possibly linked to local extirpation of black-backed jackals by farmers (Pringle and Pringle 1979, Stuart 1982, H. Berry *in litt.* 1991). In the savannah regions of west and central Africa, it is less common and patchily distributed in pockets of drier habitat (Kingdon 1977).

Protection Status

CITES Appendix II. National legislation: not protected over most of its range. Hunting prohibited: Angola, Benin, Burkina Faso, Cameroon, Ethiopia, Kenya, Mauritania, Mozambique, Nigeria, Zaire. Hunting and trade regulated: Botswana, Central African Republic, Senegal, Somalia, Tanzania, Zambia. No legal protection: Congo, Gabon, Gambia, Guinea Bissau, Ivory Coast, Lesotho, Malawi, Mali, Namibia, Niger, Rwanda, South Africa, Sudan, Swaziland, Togo, Uganda, Zimbabwe. Legal status as problem animal: Namibia, South Africa. No information: Burundi, Chad, Guinea (IUCN Environmental Law Centre 1986).

Principal Threats

Caracals are often killed for suspected predation on small livestock, although this appears to be a pervasive problem only in South Africa and Namibia. Analyses of stomach contents and scats from parts of South Africa outside the protected areas system have found domestic stock to make up a significant portion of the caracal's diet, with estimates ranging from 17-55% in different areas (Pringle and Pringle 1979, Bester 1982, Stuart 1982, Moolman 1986). Brand (1989) found that reported annual small stock losses to caracal ranged up to 5.3 animals per 10 km^2. Large numbers of animals are destroyed by farmers each year: Stuart (1982) reports that an average of 2,219 animals were killed annually in control operations in the Karoo region alone between 1931-1952. Brand (1989) surveyed problem animal hunting clubs in Cape Province, and found that numbers of caracals reported killed or captured annually ranged from 0.02-1.6/10 km^2. Farmers responding to a government questionnaire in Namibia reported killing a total of 2,800 caracals in 1981 (Joubert *et al.* 1982). However, control efforts thus far appear to have had little effect on caracal populations (N. Fairall *in litt.* 1993). Caracals typically re-colonize farming areas following local extirpation (Visser 1978).

Hunting for skins and "luxury bushmeat" is reported to be a threat in west and central Africa, where the caracal is more sparsely distributed (F. Hurst *in litt.* 1991).

African wildcat, *Felis silvestris, lybica* group (Forster, 1770)

Other Names

Chat ganté, chat sauvage d'Afrique (French); Falbkatze (German); gato montés, gato silvestre (Spanish).

Sub-Saharan Africa: Vaalboskat (Afrikaans: South Africa); ye-dw dimmet (Amharic: Ethiopia); kongo diakouma, yacoumawara (Bambara); larrouye (Bornouan); batou ana guesh, guetté (Chad); !ores (Hei//kum Bushman: Namibia); ochwi, ochawhi (Herero: Namibia); nyau (Kikuyu: Kenya); kaka pori, kimburu, kaka mwitu (Kiswahili); gamsi lala (Kotoko); /nua (Ju/hoan Bushman: Botswana, Namibia); mbaki (Luganda); ogwang burra (Luo); igola (Ndebele: Zimbabwe); moula (Sara); phah, tib, (Setswana: Botswana); nhiriri (Shona: Zimbabwe); wunndu ale (Wolof); mpaka, mbodla (Zulu: South Africa).

North Africa and Southwest Asia: Qit berri, qit el ghamli, qit wahsi (Arabic: Middle East); sooner mousch or mesch (Arabic: Sahara region); emschisch boudrar, akriw, mousch abrani (Berber); biss burree (Saudi Arabia); kadees el khala (Sudan); bisad car, jifa, mukulel dur, dinaad dur, dinad dibadeed (Somalia); tarda-tarhda, arheda, aghda (Tamahaq).

Description and Behavior (Plate 3)

The wildcat has a very large geographic range, and varies locally in appearance. In general, from north to south there is a gradation of coat thickness, intensity of ground color, and amount of "tabby" markings (Robinson 1991). Pocock (1951) recognized 26 subspecies. These subspecies are not considered in this document, which follows the taxonomy of Weigel (1961) and Hemmer (1978a) in recognizing four groups of *Felis silvestris:* the forest cats (*silvestris* group) of Europe, the Caucasus and Asia Minor; the steppe cats (*ornata* group) of south and central Asia (see *Eurasia*); the tawny cats (*lybica* group) of Africa and the Middle East; and *F. s. catus,* the domestic cat. The status of the *lybica* group throughout its range is presented here under the common name "African wildcat."

The *lybica* group is the most widespread, and these cats differ from the European forms by their lighter build, less distinct markings, and thin, tapering tails. The African wildcat is very similar in size and appearance to the domestic cat, and the two can be difficult to distinguish in the field. In southern Africa, males weigh an average of 5 kg (n=42), and females approximately 4 kg (n=36) (Smithers 1971, Stuart 1981). The background color of its coat ranges from reddish to sandy yellow to tawny brown to grey, and is typically marked with faint tabby stripes and spots. A characteristic feature of this group is a reddish or rusty-brown tint to the backs of the ears (Skinner and Smithers 1990, Harrison and Bates 1991, Dragesco-Joffé 1993).

Wildcats are primarily nocturnal, especially in very hot environments or in proximity to settled areas, but are also active in early morning and late afternoon. Studies have shown rodents to be the major prey species throughout southern Africa (Zimbabwe: Smithers and Wilson 1979; Botswana: Smithers 1971; Karoo region and Central Namib Desert: Stuart 1977; South Africa: Stuart 1982, Palmer and Fairall 1988; Natal prov., South Africa: Rowe-Rowe 1978; western Cape coast, South Africa: Avenant 1993). This prey preference is presumably similar throughout their range (Rosevear 1974, Kingdon 1977, de Smet 1989, Harrison and Bates 1991). A variety of birds, reptiles, and amphibians are also taken, as well as other mammals, including young antelope (Smithers and Wilson 1979). Insects and arachnids, including solifuges and scorpions, are frequently taken, perhaps in relation to seasonal rodent scarcity (Smithers 1971, Stuart 1977, Harrison and Bates 1991). Wildcats seldom scavenge carrion (Gasperetti *et al.* 1986, Skinner and Smithers 1990).

The African wildcat is generally recognized as the ancestor of the domestic cat (Pocock 1907a). Unlike feral domestic cats, which sometimes live in large groups or "colonies," African wildcats are solitary. Liberg and Sandell (1988) point out that domestic cats tend to form colonies in the presence of clumped, rich food resources (such as garbage dumps), remaining solitary where prey is more evenly and thinly distributed. It is interesting that in captivity, female African wildcats have assisted mothers in provisioning of young with food (Smithers 1983), a behavior observed in feral domestic cat colonies. However, preliminary results from a radiotelemetry study in Saudi Arabia indicate that wildcats persisted in solitary habits while feral domestic cats formed groups around a garbage dump. This suggests that the domestication process may be the most important factor underlying the sociality of feral cats (Macdonald *et al.* 1991), perhaps leading to a broadening of the diet to include scraps and carrion.

Biology

Birth season: (W) in southern Africa, chiefly in the summer from September-March (Skinner and Smithers 1990). In Saudi Arabia, Harrison and Bates (1991) report the capture of a pregnant female in Oman in Feb. In the northern Sahara, breeding takes place from January-March (Dragesco-Joffé 1993).

Gestation: (C) 56-63 days (Green 1991).

Litter size: (W) 3.4 (n=7, range 2-5) (Botswana: Smithers 1971); (C) 1-5.

Age at sexual maturity: (C) 11 months.

Longevity: (C) up to 15 years (Green 1991).

Habitat and Distribution

The African wildcat has a very broad habitat tolerance. It appears to be absent only from tropical rain forest: reports from this habitat type may refer to domestic cats, or possibly to hybrids (e.g. a recent report from northwestern Congo [M. Agnanga *in litt.* 1993]). It is thinly distributed throughout the Nubian, Saharan, and Arabian deserts, where it is generally restricted to mountains and dry watercourses (Gasperetti *et al.* 1986, Kingdon 1990, Skinner and Smithers 1990, K. de Smet *in litt.* 1993). Wildcats range up to >3,000 m in the mountains of Kenya, Ethiopia, and Algeria (Kingdon 1977, Yalden *et al.* 1980, Dragesco-Joffé 1993, K. de Smet *in litt.* 1993).

Density is expected to vary widely with prey availability. Mendelssohn (1989) estimated a density of one individual per km^2 in open oak forest on hilly, rocky ground in Israel. Fuller *et al.* (1988) reported the home range of a male African wildcat near Nakuru, Kenya as 4.3 km^2.

Population Status

Global: Category 5c. Regional (sub-Saharan Africa): Category 5. Regional (north Africa/Middle East): Category 5. IUCN: not listed. While *F. silvestris* is the most abundant of the felids, widespread hybridization with domestic cats is leading to the increasing rarity of pure wildcats (see below).

Protection Status:

CITES Appendix II. National legislation: not protected over most of its range. Hunting prohibited: Algeria, Israel, Mauritania, Morocco, Mozambique, Niger, Nigeria, Tunisia. Hunting regulated: Angola, Burkina Faso, Ghana, Senegal, Somalia, Tanzania, Togo. No legal protection: Benin, Botswana, Cameroon, Central African Republic, Congo, Egypt, Ethiopia, Gabon, Gambia, Guinea Bissau, Ivory Coast, Kenya, Lebanon, Lesotho, Malawi, Mali, Namibia, Oman, Rwanda, Saudi Arabia, Sierra Leone, South Africa, Sudan, Swaziland, Uganda, United Arab Emirates, Zaire, Zambia, Zimbabwe. No information: Burundi, Chad, Djibouti, Guinea, Iraq, Jordan, Libya, Qatar, Syria, Western Sahara, Yemen

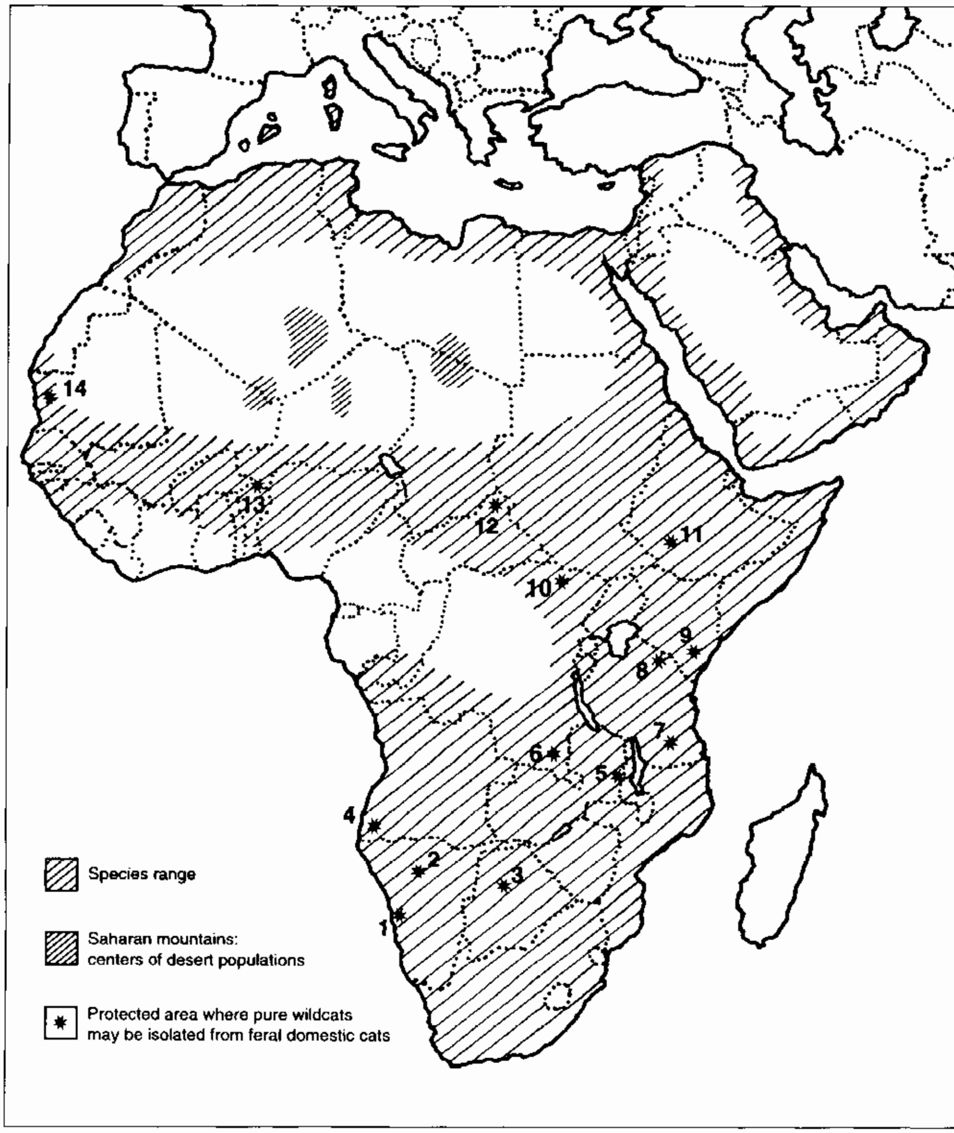

Figure 8. Distribution of the African wildcat (*F. silvestris, lybica* group).
1. Namib-Naukluft II; 2. Etosha II (Namibia); 3. Central Kgalagadi II (Botswana); 4. Iona VI (Angola); 5. N and S Luangwa II complex (Zambia); 6. Kundelungu II complex (Zaire); 7. Selous IV** complex; 8. Serengeti II# complex (Tanzania); 9. Tsavo II complex (Kenya); 10. Garamba II** (Zaire); 11. Mago II + Omo II complex (Ethiopia); 12. Manovo-Gounda-St. Floris II** complex (Central African Republic); 13. "W" II* complex (Burkina Faso, Benin and Niger); 14. Banc d'Arguin II** (Mauritania).

(IUCN Environmental Law Centre 1986; R. Daly, R. Khan, I. Nader, A. Serhal, K. de Smet *in litt.* 1993).

Occurrence in Protected Areas

It is increasingly likely that pure strains of African wildcat will be found only in protected areas remote from human habitation. Those areas which may possibly protect populations of African wildcats isolated from feral domestic cats are marked with an asterisk in Figure 8.

Principal Threats

The primary threat facing the African wildcat throughout its range is hybridization with domestic cats (see also discussions under *Eurasia*). Hybridization has been taking place over a long period of time, particularly in the north of its range where domestic cats arose thousands of years ago. Mendelssohn (1989) believes that male feral cats have a competitive advantage over male wildcats in access to estrous females, due to both their larger size and their occurrence, in many places, at higher densities. Hybridization in captivity has shown that distinctive characteristics of the African wildcat, such as its long legs and reddish-backed ears, are lost (Smithers 1983), although hybrids have been found with red-backed ears (M. Lindeque, pers. comm.1993). Smithers (1986) believes it inevitable that hybridization "will lead to the virtual extinction of the African wildcat as we know it at present."

Feral cats are found throughout the wildcat's range. Smithers (1986) reports that, in South Africa, it is now impossible to find pure wildcats anywhere in the vicinity of settlements where there are domestic cats. Smithers (1971) comments on hybrids found in Botswana with white legs and white patches on their bodies, and G. Mills (*in litt.* 1991) reported destroying such a specimen in the Kalahari at least 75 km from the nearest human habitation. J. Gasperetti (*in litt.* 1993) reports that a geologist found a litter of domestic cat kittens in the Rub el Khali (Empty Quarter: uninhabited sand desert of the southeastern Arabian peninusla), hundreds of kilometers from either water or the nearest Bedouin encampment. Several breeding programs have been started to conserve pure strains of wildcat in captivity, but the strongest hope for survival in the wild of pure wildcats lies in controlling feral cat numbers in remote protected areas.

Mendelssohn (1989) also attributes the rarity of African wildcats in Israel to their susceptibility to feline panleukopenia, transmitted by feral cats, which are generally resistant.

Action Planning

Projects 10, 15, 43, and 89.

Part I
Species Accounts

Chapter 2
North Africa and Southwest Asia

Box 1
Vulnerability Index to Species of the Region (in order of vulnerability)

Species	Habitat Association St [Mar] (Tot) Score	Geog. Range (10^6 km²)	Score	Body Size Score	Total Score	Ranking
Asiatic lion, *P. leo persica*	N: 1 [0] (1) -1	S: 0.03	-1	L -1	-3	1
Cheetah, *A. jubatus*	N: 2 [2] (4) -1	S: 1.02	-1	L -1	-3	1(A)
Serval, *L. serval*[a]	N: 3 [0] (3) -1	S: 0.27	-1	M 0	-2	2(A)
Leopard, *P. pardus*	B: 5 [3] (8) 0	M: 3.74	0	L -1	-1	3(A)
Sand cat, *F. margarita**	N: 2 [1] (3) -1	M: 5.40	0	S +1	0	4
Caracal, *C. caracal*	B: 5 [3] (8) 0	W: 7.06	+1	M 0	+1	5a(A)
Jungle cat, *F. chaus*[b]	B: 5 [3] (8) 0	M: 5.80	0	S +1	+1	5a
African wildcat, *F.s. lybica* group[a]	B: 3 [4] (7) 0	W: 8.70	+1	S +1	+2	5b

Key:

* All of this species' range lies within the region
[a] See species account in Chapter 1, Sub-Saharan Africa
[b] See species account in Chapter 3, Tropical Asia

Habitat Association
St = number of strong + significant habitats
N = Narrow (-1); B = Broad (0)
[Mar] = number of marginal habitats
(Tot) = total number of habitats

Geographic Range (in millions of km²)
S = Small (-1); M = Medium (0); W = Wide (+1)

Body Size
L = Large (-1); M = Medium (0); S = Small (+1)

(A) = Actively threatened

Regional Criteria
Habitat Association: Narrow = 1-4 habitat types; Broad = 7-8 habitat types
Geographic Range: Small = $\leq$1 million km²; Intermediate = 3-6 million km²; Wide = 7-9 million km²
Body Size: Large = 35-135 kg; Medium = 7-20 kg; Small = $\leq$6.5 kg

See the Introduction to the Species Accounts for explanation of the vulnerability ranking system (pp. 2-6).

Asiatic lion, *Panthera leo persica* (Meyer, 1826)

Other Names

Lion d'Asie (French); Asiatische Löwe (German); león de Asia (Spanish); sinh, sawaj (Gujarati); sinh, sher, untia bagh [camel tiger] (Hindi); hawaj (Maldhari); simha (Maldhari, Kannada); babar sher (Persian).

Description and Behavior (Plates 1 and 8)

This Species Account primarily concerns the Asiatic lion *P.l. persica,* but reference must be made to the Barbary (north African) lion *P.l. leo,* the nominate subspecies and the lion that appeared in Roman circuses. There appears to be no record of contiguous populations of the two subspecies in historic times. The Barbary lion is extinct in the wild—the last record being one shot in Morocco in 1920 (Grzimek 1975). Some lions in Temara Zoo in Rabat were identified in 1974 by Leyhausen and Hemmer (Leyhausen 1975) as having physical characteristics of the Barbary lion: very clear light iris, rather than brown; mane spreading behind the shoulders and covering the belly right to the groin, high occiput (back of the head), short legs, and deep chest (W. York quoted in introduction to Leyhausen 1975) but none appeared absolutely flawless (Leyhausen 1975). Attempts to establish a scientific breeding program have so far failed, although some zoos have bred specimens (W. Frey *in litt.* 1993)

Today, the only living representatives of the lions once found throughout much of southwest Asia occur in India's Gir Forest. These Asiatic lions are genetically distinct from the lions of sub-Saharan Africa, although the difference is not large, being smaller than the genetic distance between human racial groups. Based on genetic distance, the Asiatic lion is estimated to have separated from the African population as recently as 100,000 years ago, not long enough for reproductive incompatibilities to have evolved (O'Brien *et al.* 1987b,c). The most striking morphological character, which is always seen in Asiatic lions, but rarely in African lions, is a longitudinal fold of skin running along its belly (O'Brien *et al.* 1987c). In addition, male Asiatic lions have only moderate mane growth at the top of the head, so that their ears are always visible, while many African males develop full manes which completely obscure the ears. Finally, about 50% of Asiatic lion skulls from the Gir forest have bifurcated infraorbital foramina (small apertures which permit passage of blood vessels and nerves to the eyes). In African lions, there is only one foramen on either side (Pocock 1939a, O'Brien *et al.* 1987c). Asiatic lions are slightly smaller than African lions: adult Gir males weigh 160-190 kg (n=4), while females weigh 110-120 kg (n=2) (Ravi Chellam *in litt.* 1994). The record total length of a male Asiatic lion (including the tail) is 2.92 m (Sinha 1987).

Mean pride size, measured by the number of adult females, tends to be smaller than for African lions: most Gir prides contain just two adult females, with the largest having five (Walker 1994: 18), compared to averages of 4-6 for African protected areas. However, despite the small population size, individual animals are not well known; future monitoring combined with molecular analysis of relatedness could show that what are currently identified as separate prides consist instead of smaller foraging groups from larger prides. Coalitions of males defend home ranges containing one or more groups of females, but unlike African lions, Gir males generally associate with their pride females only when mating or on a large kill. A lesser degree of sociality in the Gir lions may be a function of the smaller prey available to them: the most commonly taken species (45% of known kills), the chital, weighs only around 50 kg (Johnsingh and Ravi Chellam 1991). The larger sambar deer is also frequently taken (15% of known kills), and may be preferred (Ravi Chellam 1993).

However, domestic cattle have historically been a major component of the Gir lions' diet (Pocock 1939a). Livestock hair was found in 75% of over 1,800 lion scats examined by Joslin (1973), and in 48% of those examined by Sinha (1987). The wild ungulate prey base has strongly increased since the early 1970s (see below), and this is reflected in a shift in the lions' diet: recent analysis of over 3,000 scats showed that nearly 70% contained hair of wild ungulates. A significant proportion of known lion kills (30-35%) still consists of livestock, but this is probably overestimated due to the relative ease of locating livestock kills as opposed to wild ungulate kills (Ravi Chellam 1993, Walker 1994: 11). Availability of livestock may also affect the loose sociality of Gir lions: based on 56 observations of lions at livestock kills, it appears that males prey on livestock to a greater extent than females (Ravi Chellam 1993).

Biology

Reproductive season: year-round, but based on sightings of cubs, there is a birth peak from late winter to early summer (February-early April: Ravi Chellam *in litt.* 1994).

Litter size: (W) mean 2.5, range 1-5 (observed only after young cubs are fully mobile) (Walker 1994: 18); (C) 2-6 (Chavan 1993).

Age at first reproduction: (W) field workers estimate females 4 years, males 5-8 years; (C) 3 years (males and females) (Walker 1994: 18).

Age at last reproduction: (W) females 15-16 years (Chavan 1993); (C) both sexes 15 years (Walker 1994: 18). Adult sex ratio: 1 male:2.2 females (Ravi Chellam and Johnsingh 1993a). In captivity, records from the Sakkarbaug Zoo, which maintains the largest captive population of Asiatic lions, also show a female bias (1 female: 0.38 male), but it is not known whether this is a local effect, or whether it is representative of wild conditions (Walker 1994: 18).

Juvenile mortality: (< 12 mos) (W) 33% (3 cubs of 9 from 4 litters); (C) 36% (74 of 205 cubs born at Sakkarbaug Zoo).

Adult mortality: (W) estimated at 8-10%, based on an average of 10 adult animals per year which are removed from the Gir population for health reasons and taken to the Sakkarbaug Zoo (Walker 1994: 18).

Longevity: (C) females 17-18 years but up to 21; males 16-16 years but up to over 18 (Chavan 1993).

Habitat and Distribution

The range of the lion in north Africa and southwest Asia formerly stretched across the coastal forests of northern Africa and from northern Greece across southwest Asia to eastern India (Guggisberg 1961, Joslin 1973, Smithers 1975). It became extinct in eastern Europe around A.D. 100, and in Palestine around the time of the Crusades (Guggisberg 1961). It remained widespread elsewhere until the mid-1800s, when the advent of firearms led to its extinction over large areas. By the late 1800s, the lion had disappeared from Turkey (Üstay 1990); the last reports from Iran and Iraq date to 1942 (Joslin 1973) and 1918 (Hatt 1959) respectively. In India, lions ranged east to the state of Bihar, but declined under heavy hunting pressure—Pocock (1939a) uses the diaries of an English officer who shot 300 lions during the 1857 Indian Mutiny as an example. By the turn of the century, the Asiatic lion was confined to the Gir Forest, where it was protected by the Nawab of Junagadh in his private hunting grounds (Kinnear 1920).

The Gir is dry deciduous forest dominated by teak, the predominance of which is partially due to the silvicultural practices of the Gujarat State Forest Department, which permits logging and replants clear-cut areas with teak (Berwick 1976). The drier eastern part of the Gir is vegetated with acacia thorn savannah and receives about 650 mm annual rainfall; rainfall in the west is higher at about 1,000 mm a year (Ravi Chellam and Johnsingh 1993a). The forest, which covered about 2,600 km^2 at the turn of the century (Oza 1983), has since shrunk to less than half this size. Most of the remaining forest is included in the Gir National Park and Wildlife Sanctuary (259 + 1,153 = 1,412 km^2). The Gir Forest is the last representative block of the natural vegetation of the semi-arid Saurashtra peninsula, and is surrounded by cultivation. Moreover, about 7,500 people and their 14,000 head of livestock live in the wildlife sanctuary which surrounds the core national park. Within a 10 km radius surrounding the sanctuary boundary, there is a human population of 160,000 and about 100,000 head of livestock (Walker 1994: 13-14). During drought years in the past, cattle have been brought to graze in the protected area from hundreds of kilometers away, with numbers reaching up to 70,000 (Berwick 1976); the average annual number of seasonally grazing livestock in the park is currently estimated at 20,000 (Walker 1994: 14).

The pastoralist Maldharis, who make up about one-third of the reserve's human population, have been part of the Gir ecosystem since approximately 1860 (Berwick 1976). Their primary means of subsistence is selling ghee (clarified butter used for cooking). However, livestock overgrazing has led to soil impaction and erosion, as well as xerification of the forest. Berwick (1976) found that, contrary to popular assumption, overgrazing was not leading to a decline in wild ungulate populations. Wild ungulates were found to feed mainly on woody plants rather than grasses, and it was concluded that lion predation was the primary factor limiting their numbers, then estimated at 6,200 (Berwick 1974). However, despite Berwick's findings, with the removal of some 845 Maldhari familes and their herds, wild ungulates have greatly increased, and are currently estimated at 43,000, including some 38,000 chital (Rashid 1984, Khan *et al.* 1990, Ravi Chellam and Johnsingh 1993a).

Population Status

Global: Category 3(A). Regional: Category 1. IUCN: Endangered. The Gir lion population had been reduced to a very low number by the early years of the 20th century: fewer than 20 according to the Chief Forester of Junagadh (Winter-Blyth 1949). However, Gee (1964) reported the "certainty" of the neighboring ruler, the Jam Saheb of Nawanagar, that there were about 100 lions, and that the ruler of Junagadh gave low numbers in order to dissuade would-be trophy hunters.

The first census, calculated on the basis of individually recognizable pug marks, was conducted in 1936, and yielded an estimate of 234 adults (Winter-Blyth and Dharmakumarsinhji 1951). Subsequent censuses, based on counts of animals at live buffalo baits, estimated the population at around 100 adults between 1968-1979. Censuses based on counts of animals both at waterholes and baits conducted in 1985 and 1990 indicate that the population is increasing, with 191 adults (66 males, 75 females, 50 sub-adults) counted in 1985, and 221 adults (99 males, 122 females, sub-adults not distinguished) in 1990. In addition, about 30-40 lions are believed to live in the agricultural mosaic surrounding the reserve boundaries (Chavan 1993, Walker 1994: 5). The accuracy of the waterhole count technique has been questioned (Kunte

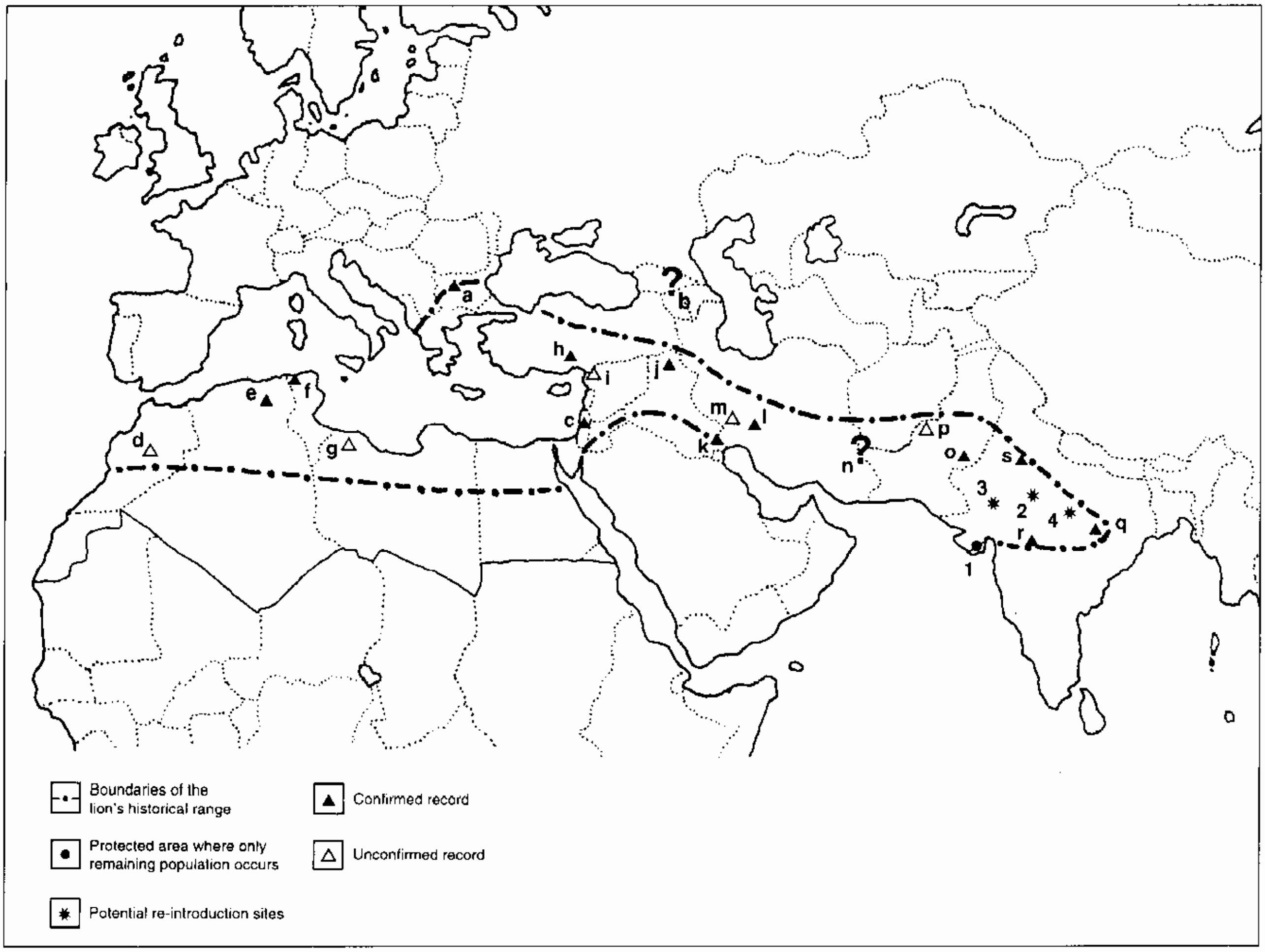

Figure 1. Past and present distribution of the lion (*P. leo*) in north Africa and southwest Asia.

Historical range: Source is Guggisberg (1961) unless stated otherwise. a. Aristotle and Herodotus wrote that lions were found in the Balkans in the middle of the first millenium B.C. When Xerxes advanced through Macedonia in 480 B.C., several of his baggage camels were killed by lions. Lions are believed to have died out within the borders of present-day Greece in A.D. 80-100. b. Lions were probably found in the Azerbaijan area up to the 10th century A.D. Their disappearance from the reed thickets and pistachio and juniper forests is primarily associated with an increase in human population and a change in environmental conditions, which in turn led to the decline of ungulates in the region (Heptner and Sludskii 1972). c. Lions could still be found in the vicinity of Samaria in the 12th century. d. Lions disappeared from the Moroccan coast by the mid-1800s. They may have survived in the High Atlas Mountains up to the 1940s. e. Last known lion in Algeria killed in 1893 near Batna, 97 km south of Constantine. f. Last known lion killed in Tunisia in 1891 near Babouch, between Tabarka and Aïn-Draham. g. Lions were extirpated from Tripolitania as early as 1700. h. Last known lion in Turkey killed in 1870 near Birecik on the Euphrates (Üstay 1990). i. Sir Alfred Pease reported that lions still existed west of Aleppo, Syria, in 1891 (Kinnear 1920). j. Lions occurred in the vicinity of Mosul, Iraq, in the 1850s. The Turkish governor's bag of two in 1914 is the last report of them from the area (Kinnear 1920). k. Lions were reported to be numerous in the reedy swamps bordering the Tigris and Euphrates rivers in the early 1870s. The last known lion in Iraq was killed in 1918 on the lower Tigris (Hatt 1959). l. The valley of Dashtiarjan, 57 km west of Shiraz in Iran, was famous for its lions in the late 1800s. m. The last known report of lion presence in Iran was a 1942 observation of a pair near Dizful, by American engineers building a railway (Heaney 1943). n. There are no confirmed modern records of lion presence in central or eastern Iran, nor Afghanistan or Baluchistan. o. The last known lion in Pakistan killed near Kot Deji in Sind province in 1810. p. However, a British admiral travelling by train reported seeing a maneless lion near Quetta in 1935, eating a goat: "It was a large lion, very stocky, light tawny in colour, and I may say that no one of us three had the slightest doubt of what we had seen until, on our arrival at Quetta, many officers expressed doubts as to its identity, or to the possibility of there being a lion in the district". q. The lion's range may have extended as far east as Bihar and Orissa states: a lion was reportedly killed in the district of Palamau (Bihar) in 1814. r. Last lion recorded from the southern end of its Indian range killed at Rhyl in Damoh district, near the Narmada river, in the cold season of 1847-1848 (Kinnear 1920). s. Fifty lions were killed in the district of Delhi between 1856-1858. Twenty-five years later Blanford (1891) wrote that "in India the lion is verging on extinction."

Present range: 1. Gir II complex. Potential reintroduction sites: 2. Palpur Kuno (Kuno) IV; 3. Sitamata IV. Site of unsuccessful reintroduction in the 1960s: 4. Chandraprabha IV.

and Gore 1986). The most reliable method would be to mark individuals, which could lead to improved understanding of population dynamics (Walker 1994:10).

Radio-telemetry studies (Ravi Chellam 1993) estimate the mean annual home range of male lions at 110 km^2, and females at 50 km^2. The ranges of male coalitions are between 100-150 km^2 in size, while those of single males are smaller at 50 km^2 (Chavan 1993). Density is estimated at one lion per 7 km^2, which would yield a population of 202 adults, a total very close to the 1990 census result (Ravi Chellam 1993). This density is comparable to the upper range of estimates of lion density in sub-Saharan Africa. For comparison, tiger densities in good habitat with abundant prey and low numbers of interspecific competitors (Kanha National Park, India and Royal Chitwan National Park, Nepal) are of the order of one tiger per 11-17 km^2 (Schaller 1967, Sunquist 1981, Smith 1984, Karanth 1987). The number of lions appears to have exceeded the estimated carrying capacity of 200-250 animals (Ravi Chellam 1987, Rashid 1991, Chavan 1993, Walker 1994: 5).

Genetic studies (O'Brien *et al.* 1987b) of 28 lions from India's Sakkarbaug Zoo (four wild-born founder animals and 24 offspring of nine, including the four sampled, original founders) revealed total genetic uniformity among the animals, similar to that found for cheetahs (O'Brien *et al.* 1986). A high incidence of spermatozoal abnormalities has also been found for both wild and captive Asiatic lions (O'Brien *et al.* 1987c, Wildt *et al.* 1987b, Fouraker and Wildt 1992). No signs of compromised reproduction in the wild have been reported (P. Jackson, pers. comm.), but Walker (1990, 1994) has noted high rates of infant mortality among the inbred Sakkarbaug Zoo lions. On the other hand, hybrid African-Asiatic lions breed well in captivity (O'Brien *et al.* 1987c).

Protection Status

CITES Appendix I. National legislation: fully protected in India (Ravi Chellam and Johnsingh 1993b).

Principal Threats

The close proximity of predators, livestock, and humans in the Gir Forest gives rise to a number of management problems which threaten the Asiatic lions. There are four large temples located in the Gir Forest, which is cut by five major roads and a railroad, so that a considerable volume of people moves through the protected area. Lopping of tree branches for firewood is widespread, and is having a devastating effect, especially upon riverine forest, which is prime habitat for lionesses with cubs during the dry season (Ravi Chellam 1993). Lions have been preying on cattle ever since they first moved into the area, but there are indications that peoples' tolerance of lions is coming to an end. The government's livestock loss compensation scheme is cumbersome and unrealistic (Joslin 1984, Ravi Chellam and Johnsingh 1993a), and there are recent reports of villagers killing lions.

Even more alarming, the lions which have long been famed for their docility toward humans have recently begun to attack people, mainly during sorties outside the sanctuary. Saberwal (1990) has documented 81 attacks resulting in 16 deaths from January 1988-April 1990, as compared to 65 attacks resulting in eight deaths over the previous decade. He suggested that the spate of attacks was attributable to reduced availability of livestock prey due to the effects of a severe drought in 1987-1988, and noted that the attacks were clustered near 1) high human population density and 2) sites where lions were baited until 1987 to show them to tourists. Lions in these areas, familiar with large groups of people, would have been less sensitive to human threats, and thus more likely to have become involved in conflicts over livestock. Ravi Chellam and Johnsingh (1993a) stress that greater involvement of the impoverished Maldharis and villagers in and around the Gir in the management of the protected area is a matter of highest priority.

The Asiatic lion currently exists as a single population, and is thus vulnerable to extinction from unpredictable events, such as an epidemic or large forest fire. However, it is also a large, healthy population, and a recent Population and Habitat Viability Analysis (PHVA) workshop in India (Walker 1994) predicted a zero percent chance of extinction over the next 100 years, based on their population model.

Nonetheless, establishment of at least one other wild population is advisable for population safety, for maximizing genetic diversity, and in terms of ecology (re-establishing the lion as a component of the fauna in its former range). The Asiatic lion PHVA (Walker 1994) reviewed several potential translocation sites for suitability in terms of habitat and prey base, and selected the Palpur-Kuno Wildlife Sanctuary in northern Madhya Pradesh as the most promising (this and other potential sites are shown as stars on the distribution map). The size of the protected area is currently only 345 km^2, but it could be expanded to approximately 2,000 km^2 if adjacent forest were incorporated. Human disturbance is considered to be relatively low—although there are still 13,000 people and 16,000 livestock in the proposed area. Moving them out, as was done in several Tiger Reserves, would no doubt be extremely difficult. Moreover, there is considerable hostility to wildlife in rural India, and moving lions into an area where people have had no experience of them for generations is risky, both for the lions themselves and for the larger cause of big cat conservation. A previous attempt to establish a second population in the Chandraprabha Wildlife Sanctuary in eastern Uttar Pradesh appeared to be succeeding, as the population grew from three to 11 animals, but then the lions disappeared, presumably shot or poisoned (Negi 1969).

Theoretically, the captive population of Asiatic lions can be considered to represent a second population. A Species Survival Plan (SSP) was established by the American Zoo and Aquarium Association (AZA) to manage the >200 Asiatic lions held by western zoos. However, not only is this SSP-managed population entirely descended from five founder animals, but two of the founders were African or African-Asiatic hybrids, as demonstrated by genetic studies and morphological characteristics (O'Brien *et al.* 1987c). Only three individuals in North American zoos are of pure bloodline (Wildt *et al.* 1992a). The total global captive population of pure Asiatic lions is believed to be 82, of which 23 are held outside of India (Walker 1994: 21). The government of India is currently considering offering problem wild lions to western zoos as new founders. The AZA's Felid Taxon Action Group has recommended that hybrid lions may continue to be bred to monitor their vigor until such time as space is required for pure Asiatic lions. It also called for collection of germ plasm from wild animals, which could be used to infuse genetic diversity into the captive population (Wildt *et al.* 1992a: 80).

Action Planning
Project 35.

Cheetah, *Acinonyx jubatus* Schreber, 1776

Other Names
Guépard (French); Gepard (German); guepardo, chita (Spanish); fahad (Arabic); yeoz (Brahui: Pakistan); pulam (Bukharian & Turkmenian); chita, laggar (Hindi: India); tazy palng (Dari: Afghanistan); yuz, yuz peleng (Farsi: Iran); ala bars, pyestrai, or pyatnistai bars (Kazakh); gurk (Mekrani: Pakistan); tazy prang (Pashto: Afghanistan); Asiaskii gepard (Russian); adèle amayas (Tamahaq, Tamacheq [Touareg]): Northwest Sahara); myallen, koplon (Uzbek).

Description and Behavior (Plate 8)
See full species account under *Sub-Saharan Africa*. Some authorities consider the cheetahs of north Africa and southwest Asia to be a single race, *A.j. venaticus* (Pocock 1939a, Ellerman and Morrison-Scott 1951), while others argue that north African populations have only become isolated from populations at the southern edge of the Sahara within the last century (K. de Smet *in litt.* 1993). Harrison and Bates (1991) label the distinction between Asian and African cheetahs dubious, while other anatomists consider Asian cheetahs to differ in morphology (Hemmer 1988) and pelage (pale fawn as opposed to sub-Saharan yellow, with spots more widely spaced: Heptner and Sludskii 1972, C. Groves in Karami [1992]). Dragesco-Joffé (1993) has observed that cheetahs of the open, sandy Saharan desert tend to be pale, with ochre rather than black spots, and muted "tear line" and tail rings. There is a rare form, locally called "white cheetah," which is exceptionally pale. However, cheetahs living around the black rocks of the Saharan mountain ranges tend to retain the black spots common to sub-Saharan cheetahs. Dragesco-Joffé has also reported that Saharan cheetahs tend to be rather small: two adult males killed in the Ténéré region of Niger had a shoulder height of only 65 cm, as compared to 85 cm for sub-Saharan cheetahs (Bowland *et al.* 1993). The genetics of north African and southwest Asian cheetahs have yet to be investigated.

While the question of evolutionary relationships remains to be resolved, the main difference between cheetahs of this region and those south of the Sahara is that they are much more rare. Some of this rarity is natural, given the harsh conditions of sand desert. However, severe depletion of the cheetah's ungulate prey base (East 1992a, b) and direct persecution are the major threats to the cheetah's survival in this region.

There is little information available on the ecology of these cheetahs. Gazelles are generally indicated as the main prey species (Heptner and Sludskii 1972, Harrison and Bates 1991). In India, cheetahs took primarily blackbuck antelopes and chinkara gazelles, but were also known to attack nilgai antelope and domestic goats and sheep (Pocock 1939a). In Turkmenistan, cheetahs primarily took goitered gazelles, and their disappearance from this area is strongly associated with the decline of gazelles in the mid-1900s (Heptner and Sludskii 1972). In Iran, cheetahs outside protected areas with gazelle populations are reported to prey mainly on hares, an abundant food source because they are not usually taken by Muslim hunters (M. Karami *in litt.* 1990). Cheetahs in sub-Saharan Africa are known to take hares opportunistically. Whether cheetahs can subsist almost entirely on small prey needs to be investigated.

Dragesco-Joffé (1993) reported that cheetahs living in the Saharan mountains often hunt at night, when temperatures are cooler. He translates the Touareg name for cheetah as "one who advances slowly"—a reversal of the popular perception of the cheetah as one of the fastest land mammals. The name is a tribute to the cheetah's slow, patient stalking of gazelles in open terrain with very little cover. Dragesco-Joffé also states that Saharan cheetahs occasionally take ostrich and Barbary sheep.

Throughout this region and in Europe as well, captive cheetahs were kept by the nobility and trained to hunt, a practice dating back about 5,000 years to the Sumerians.

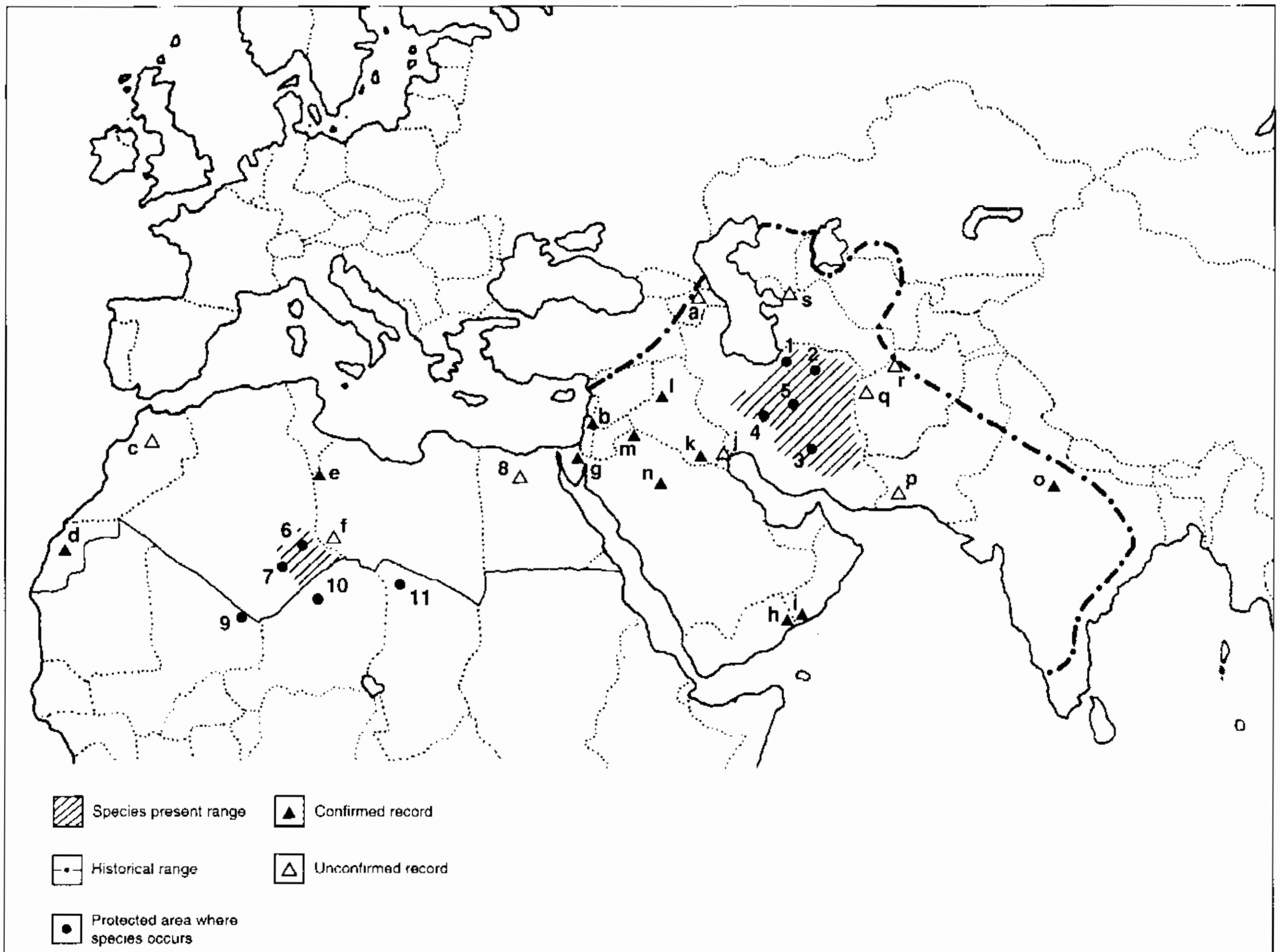

Figure 2. Past and present distribution of the cheetah (*A. jubatus*) in north Africa and southwest Asia.

Historical range: a. The Azerbaijan khans and Armenian and Kartlian (eastern Georgian) princes hunted with trained cheetahs up to the 14th century. In 1472, Josef Barbaro saw the "100" hunting cheetahs of an Armenian prince. The Georgian Chronicles (Kartlis Tskhovreba) place the cheetah in eastern Georgia in the Middle Ages. Fossil remains dating to the middle Pleistocene document the cheetah's presence in the Caucasus region, but it is unclear whether wild cheetahs persisted there in historical times (Vereschagin 1959). b. Tristram (1866, cited in Harrison and Bates 1991) noted the presence of a few cheetahs in Gilead, the vicinity of Mt. Tabor and the hills of Galilee, but cheetahs have been extinct in this area for over 100 years (Harrison and Bates 1991). c. Cheetahs were still found up to 40 years ago in the Atlas mountains of Morocco (Wrogemann 1975). d. The last record for the cheetah in Western Sahara dates to when an animal was captured in 1976 and given to the Algiers Zoo. e. The last known cheetah in Tunisia was killed in 1960 near Bordj Bowrgiba in the extreme south of the country. f. The last observation of a cheetah in Libya was in 1980 in the southwestern part of the country bordering Algeria, where cheetahs are still known to exist (K. de Smet, pers. comm. 1990, cited in Kraus and Marker-Kraus 1991). g. Hardy (1947) mentions seeing two cheetahs in the Sinai Desert in 1946. h Last record of the cheetah in Yemen dates to an observation by J.T. Ducker in 1963 in Wadi Mitan (Harrison and Bates 1991). i. Last known cheetah in Oman shot near Jibjat, Dhofar in 1977 (Harrison 1983). j. Dickson (1949) remarked on the presence of cheetahs in Kuwait. k. Cheetahs were reported to be rare in the desert west of Basra, Iraq, in 1926 (Corkill 1929). l. Last record of the cheetah in Iraq is a photograph of one killed by a car between the H1 and H2 pumping stations (Harrison and Bates 1991). m Cheetahs were killed in the early 1950s by oil workers near the Saudi Arabian, Jordan and Iraq border intersections (Hatt 1959). n. Last record for the cheetah in Saudi Arabia dates to 1973, when two were killed near Ha'il and exhibited for a few days near the Imara palace (Nader 1989). o. The last record of the cheetah in India, where the species was formerly widespread, dates to 1947, when the Maharajah of Korwai (misprinted as "Korea" in *J. Bombay Nat. Hist. Soc.* Vol. 47:719) in northern Madhya Pradesh, shot three cheetahs (with two bullets) at night, spotlighting them with his car headlights. Taxidermists van Ingen and van Ingen (1948) transmitted the "record of this shoot" in a letter to the Journal of the Bombay Natural History Society. The editors appended a note saying, "The editors were so nauseated by the account of this slaughter that their first impulse was to consign it to the waste-paper basket. Its publication here is intended in the nature of an impeachment rather than any desire on their part to condone or extol the deed." p. Cheetahs formerly occurred throughout the dry hills west of the Indus river in Pakistan at the end of the 19th century, but subsequent reports are sparse and they are probably now extinct (T. Roberts *in litt.* 1993). The last record is of a trade skin obtained

Continued on next page

in 1972, which reportedly originated from the Mekran border region near Iran (Roberts 1977, Groombridge 1988). q-r. Habibi (1977) and Sayer and van der Zon (1981) believe the cheetah to be extinct in Afghanistan, where it was formerly found throughout the lower steppes up to 1,000 m. Skins were purchased in fur markets in Fara (q) in 1948 and in Herat (r) in 1971, but their origin is not known. s. The cheetah has disappeared in recent times from the trans-Caspian region (Bannikov and Sokolov 1984). It was probably extirpated from the Kyzylkum desert region southeast of the Aral Sea in the early 1960s, and from the Ustyurt and Mangyshlak regions west and southwest of the Aral by the late 1970s (Ishadov 1992; E. Matjuschkin, E. Mukhina *in litt.* 1993). The last unconfirmed observation of a cheetah in this region dates to 1982 on the Turkmenistan-Kazakhstan border (s); the last confirmed evidence of a small, established population dates from 1973 in Turkmenistan, further south on the Uzboy dry watercourse on the edge of the Karakum desert (Anon. 1985).

Present range: 1. Khoshyeylag I; 2. Miandasht I + Touran V* complex; 3. Bahramgor IV; 4. Moteh V; 5. Kavir II* complex (Iran); 6. Tassili N'Ajjer II#; 7. Ahaggar II (Algeria); 8. Possible cheetah tracks seen in the Qattara Depression, Egypt (Amman 1993); 9. Adras des Iforas Mts. reserve (proposed: Mali); 10. Aïr & Ténéré VIII (Niger); 11. Tibesti Massif (not protected: Chad).

In India, the Moghul Emperor, Akbar, is reputed to have collected some 9,000 animals in his lifetime. According to Pocock (1939a), the animals were better captured adult for this purpose, after having learned to hunt from their mother. By the early 1900s, however, Indian cheetahs had become so scarce that imports of African animals were required to sustain the princes' stables (Divyabhanusinh 1984), as there was no success breeding them in captivity (see also Part II Chapter 5).

Habitat and Distribution

Cheetahs were once widely distributed across the region, absent only from extensive sand plains and massifs, and from areas of dense tree and shrubby vegetation (Heptner and Sludskii 1972). At present, only two main population concentrations can be confirmed: in the southwestern Sahara and in Iran (Fig. 2). In the southern Sahara, mountain ranges in Algeria, Chad, Mali, and Niger form the cheetah's stronghold, although they can range far out onto sandy plains where there is sufficient prey. Cheetahs have been observed at elevations up to 2,000 m in the rocky mountains (Kowalski and Rzebik-Kowalska 1991, Dragesco-Joffé 1993, K. de Smet *in litt.* 1993). In Iran, there are reliable recent records of cheetahs from the provinces of Khorasan (northeastern part of the country), Markazi (central), and Fars (southwest) (Karami 1992).

It is possible that cheetahs occur sporadically in other parts of the Saharan and southwest Asian regions (such as Egypt's Qattara Depression, where tracks possibly made by a cheetah were recently found [Ammann 1993]), but most records date back at least 20 years (see Fig. 2 caption). In southwest Asia, the locations of the greatly reduced gazelle populations are fairly well-known (East 1992b), and it is unlikely that cheetahs would be overlooked. In north Africa, the situation is more optimistic: although no longer common, the dorcas gazelle (which cheetahs in Algeria have been observed to prey upon: Dragesco-Joffé 1993, K. de Smet *in litt.* 1993) still occurs widely in certain parts of Egypt, locally in Libya, and in the southern deserts of Tunisia (East 1992a).

In Iran, cheetahs are found mainly in the central shrub steppe, a broad zone of bush and grassland where most of Iran's cities are located. It snows in the winter. The Saharan mountains are hyper-arid, but still receive slightly higher rainfall than the surrounding desert. They are thus better vegetated and support small permanent waterholes and antelope populations (Swift 1975, Le Berre 1991).

Population Status

Global: Category 3(A). Regional: Category 1(A). IUCN: Endangered. Cheetahs were probably extirpated in the following countries during the mid- to late 1900s: Afghanistan, Iraq, Israel, Jordan, Libya, Kuwait, Morocco, Oman, Pakistan, Saudi Arabia, Syria, Tunisia, Turkmenistan, Uzbekistan, Western Sahara, and Yemen (Wrogemann 1975, Kraus and Marker-Kraus 1991: see Fig. 2). A small, isolated population may persist in Egypt's Qattara Depression (IUCN 1976, Kraus and Marker-Kraus 1991, Ammann 1993).

De Smet (1989) estimates that "several dozen" cheetahs persist in the mountains of southeastern Algeria, and it is not clear whether the population is isolated from that centered on the Aïr massif 500 km to the south in Niger. There are no records of cheetahs from the extreme south of Algeria (Kowalski and Rzebik-Kowalska 1991, K. de Smet *in litt.* 1993). Dragesco-Joffé (1993), based on his travels in the region, estimated the number of cheetahs remaining in Chad, Mali, and Niger to be between 300 and 500—however, most of these animals are found in the sub-Saharan dry woodland Sahel region (J. Newby, pers. comm.). Millington and Anada (1991) estimated the number of cheetahs in Niger, concentrated in the Aïr and Termit desert regions and the Sahelian "W" National Park, at 200. In Iran, B. Dareshuri estimates the Iranian population to be fewer than 50, with the northeastern province of Khorasan being the stronghold (Karami 1992). The population has declined steeply in recent years: there were said to be over 200 cheetahs in Iran in the mid-1970s (E. Ferouz, pers. comm. 1974), although some experts consider this figure an over-estimate (P. Joslin, pers. comm.).

Various proposals have been put forward to re-stock depleted areas with cheetahs of sub-Saharan stock (e.g.

Israel, India, Turkmenistan, and Uzbekistan), but conserving extant populations is the priority. In addition, reintroduction should not be seriously considered until genetic comparisons (Hemmer 1988) and environmental impact evaluations have been carried out. The advice of the IUCN/SSC Reintroduction Specialist Group should be obtained.

Protection Status

CITES Appendix I. National legislation: protected over its known extant range, and in many historical range states. Hunting prohibited: Algeria, Egypt, Iran, Kazakhstan, Morocco, Mali, Niger, Pakistan, Sudan, Tunisia, Turkmenistan, Uzbekistan. No information: Iraq, Libya, Mauritania, Jordan, Oman, Saudi Arabia, Syria, Yemen (IUCN Environmental Law Centre 1986, Nichols *et al.* 1991, E. Mukhina *in litt.* 1993).

Principal Threats

The cheetahs of Iran and the Sahara exist in very low numbers, divided into widely separated populations. Their low density makes them particularly vulnerable to reduction of antelope prey through livestock overgrazing and hunting, coupled with direct persecution (cheetahs prey on livestock, especially young camels: K. de Smet, pers. comm.). While protected areas comprise a key component of cheetah range, management needs to be improved. For example, grazing of domestic stock is reported to be particularly serious in Iran's Khosh Yeilagh Reserve (Karami 1992), once known to hold an important resident cheetah population (Harrington 1977).

Cheetahs native to north Africa and southwest Asia are not known to be held in captivity.

Action Planning

Projects 36, 37, and 78.

Leopard, *Panthera pardus* (Linnaeus, 1758)

Other Names

Panther (English); léopard, panthère (French); Leopard, Panther (German); leopardo, pantera (Spanish); alym (Abkhazian); prang, palang, dikho (Afghanistan); nimr (Arabic); anzariuts, indz, hovaz (Armenian); jiki (Georgia); namer (Israel); pling (Kurdish); plang, palang kouh (Persian); bars (Russian); pars, kaplan, panter (Turkey); koplon (Uzbek).

Description and Behavior

See main species account under *Sub-Saharan Africa*. Across their wide range in north Africa and southwest Asia, leopards have so far been studied only in Israel's Judean Desert, a pristine mountainous region bordering the Dead Sea, where 6-9 individuals have been radio-collared and monitored since 1979 (Ilani 1990). These leopards prey mainly on rock hyrax, followed by ibex and porcupine. Ilani (1981) observed a female leopard hunt hyrax by leaping blindly over large boulders, surprising a group of hyrax on her fourth attempt and killing a young male. Roberts (1977) records an incident of a pair of leopards attacking a camel in Baluchistan, but describes more typical prey as smaller female and sub-adult Sind ibex and markhor, as well as porcupine. Ibex and hyrax were also reported, along with the Arabian red-legged partridge, to be the principal prey of leopards in Oman (Daly 1990). Wild pig were reported as major prey in the forests of northern Algeria (Kobelt 1886, cited in Kowalski and Rzebik-Kowalska 1991) and northern Iran (Joslin 1990a). In the Caucasus mountains, leopards are believed to prey primarily on wild goats and moufflon (M. Akhverdian *in litt.* 1993). In Turkmenistan, the leopard's range almost totally coincides with that of Turkmenian sheep (Heptner and Sludskii 1972), but where these have been depleted wild boar are the major prey (Lukarevsky 1993).

Leopards from the Arabian peninsula are pale in color and of small average size (Harrison and Bates 1991). Further north, in the Judean Desert, one male leopard weighed 30 kg and two females averaged 23 kg (Ilani 1981). Leopards attain larger size in the mountains of Iran and central Asia, with recorded weights for males up to 90 kg (Harrington 1977). Leopards in these areas are often referred to as "snow leopards" in local parlance because of their light color and long-haired winter coat (Ognev 1935, Hatt 1959, Harrington 1977)

Habitat and Distribution

Leopards are believed to be absent from the true desert of the central Arabian peninsula (Harrison and Bates 1991), although they are found near the Dead Sea, where annual rainfall is less than 50 mm (Ilani 1990). Pine forest and Mediterranean scrub are also suitable habitats for the species in northwest Africa (Drucker 1990, Kowalski and Rzebik-Kowalska 1991), Iran (Joslin 1990a), and the Caucasus (Ognev 1935). Throughout the region they are confined chiefly to the more remote montane and rugged foothill areas (Fig. 3), ranging up to 1,800 m in Turkmenistan (Bragin 1990), 3,000 m in Morocco (Drucker 1986), 2,600 m in Saudi Arabia (Biquand 1990) and 3,200 m in Iran (Misonne 1959).

Population Status

Global: Category 5a(A). Regional: Category 3(A). IUCN: South Arabian subspecies *nimr* Endangered (Oman, Saudi Arabia, Yemen); North Persian subspecies *saxicolor*

Table 1
Leopard Population Status by Country

Country	Population Estimate	Reference
Extinct, or No Resident Populations		
Lebanon		A. Serhal *in litt.* 1993
Libya		Hufnagl 1972
Syria		Kumerloeve 1975
Tunisia		Shoemaker 1993
United Arab Emirates		M. Reza Khan *in litt.* 1993
Small Populations, Rare and Threatened		
Algeria		K. de Smet *in litt.* 1993
Armenia		Airumyan and Gasparyan 1976, M. Akhverdian *in litt.* 1993
Azerbaijan		Alekperov *et al.* 1977
Egypt		Osborn and Helmy 1980
Georgia		Chykovany *et al.* 1990, A. Bukhnicashvili *in litt.* 1993
Israel	17	H. Mendelssohn *in litt.* 1993
Morocco		Drucker 1990
Oman		Daly 1990
Saudi Arabia		Biquand 1990; S. Biquand, J. Gasperetti, I. Nader *in litt.* 1993
Tajikistan		Lukarevsky 1990
Turkey		Akin 1989, 1991; Anon. 1989c, Ullrich and Riffel 1993; S. Umar *in litt.* 1993
Uzbekistan		Lukarevsky 1990
Yemen		Nader 1989, Biqand 1990
Populations Relatively Larger, But Still Rare and Confined to Montane Areas		
Afghanistan		Habibi 1977, MacPherson and Fernando 1991
Iran		Joslin 1990a
Pakistan		Roberts 1977, Groombridge 1988
Turkmenistan	130-150	Lukarevsky 1990
No Recent Information		
Iraq		
Kuwait		
Jordan		
Western Sahara		

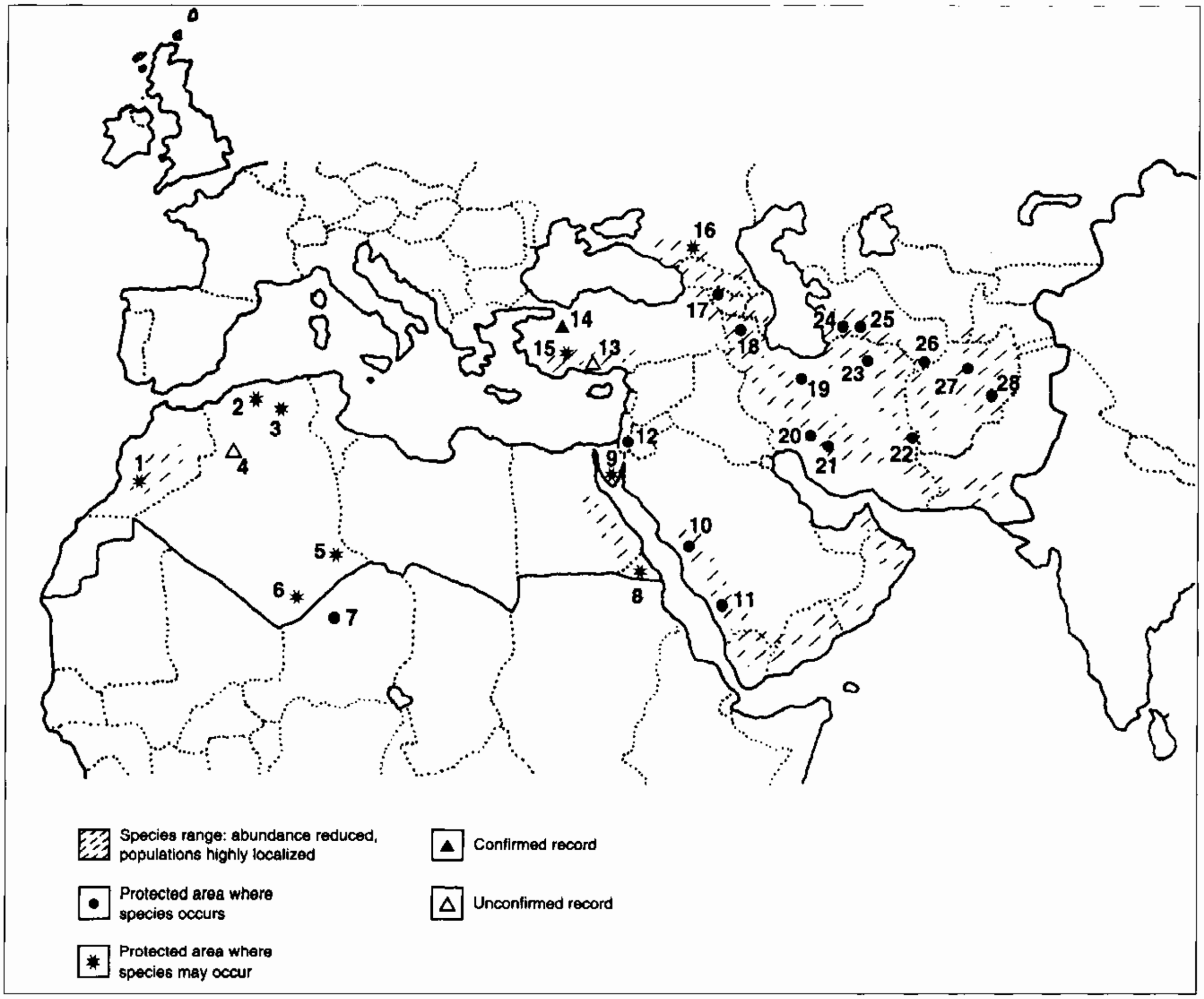

Figure 3. Distribution of the leopard (*P. pardus*) in north Africa and southwest Asia.
1. Toubkal V (Morocco); 2. Djurdjura II; 3. Belezma II; 4. unconfirmed observation from Ain Sefra (Saharan Atlas) (K. de Smet *in litt.* 1992); 5. Tassili N'Ajjer II#; 6. Ahaggar II (Algeria); 7. Aïr Ténéré VIII (Niger); 8. Gebel Elba IV (Egypt & Sudan); 9. St. Catherine (Moussa) IV (Egypt); 10. Al Fiqrah Protected Area; 11. Asir V (Saudi Arabia); 12. Judean Desert IV (Israel); 13. Sighting near Alanya in 1991 (Ullrich and Riffel 1993); 14. Leopard shot in 1974 near Beyzpari (Anon. 1989c); 15. Termessos II (Ullrich and Riffel 1993) (Turkey); 16. Kabardino-Balkarsk I (Russia); 17. Khosrovsk I (Armenia); 18. Kiamaky I; 19. Kavir II* complex; 20. Kolahghazi I; 21. Bakhtegan I; 22. Hamoun V; 23. Touran V* complex (Iran); 24. Syunt-Khasardag I complex; 25. Kopetdag I; 26. Badhkyz I (Turkmenistan); 27. Ajar Valley IV; 28. Pamir-i-Buzurg IV (Afghanistan).

Indeterminate (Afghanistan, Iran, Turkmenistan). Other "subspecies" in the region can also be considered Endangered: the Anatolian leopard *tulliana* in western Turkey, the Caucasus mountains leopard *ciscaucasia*, and the Sinai leopard *jarvisi* of southern Israel and the Sinai. Leopards have fared better than the other big cats—lion, tiger, cheetah—which historically occurred in the region. The tiger is extinct, the lion is represented by a single population in India, and the cheetah's range is a small fraction of what it once was. However, the future of the leopard is far from secure. Throughout the region, leopards generally exist as small, threatened, and widely separate and isolated populations (Shoemaker 1993).

Protection Status

CITES Appendix I. National legislation: lacking information. Hunting prohibited: Algeria, Armenia, Egypt, Georgia, Iran, Israel, Jordan, Morocco, Pakistan, Russia, Saudi Arabia, Turkmenistan, Uzbekistan. No legal protection: Lebanon, Oman, Tunisia, Turkey, United Arab Emirates. No information: Afghanistan, Azerbaijan, Iraq, Libya, Kuwait, Syria, Tajikistan, Yemen (IUCN Environmental Law Centre 1986, Shoemaker 1993; M. Akhverdian, A. Bukhnicashvili, E. Mukhina, A. Serhal *in litt.* 1993).

Principal Threats

Small isolated populations are vulnerable to disruption of healthy population dynamics, as has been documented by Ilani (1990) for the leopards of the Judean Desert. In 1978, the population of roughly 20 individuals—a low number to begin with—had a sex ratio of one adult male: 2.5 females. Since then, four females were killed by humans, and the only surviving cubs were two males. As of 1989, there had been no recruitment since 1984, as all cubs born to the one fertile female were killed by the father, and no immigration has been recorded from the adjacent population in the Negev Desert. Moreover, there were three different cases of a female mating and producing cubs with her son and, by 1989, there remained only two adult females in the population, both too old to breed.

The ungulate prey base throughout the region has in many places been severely reduced (East 1992a, b), which probably accounts at least in part for the leopard's widespread reputation as a killer of domestic stock (Hassinger 1965, Roberts 1977, Harrison and Bates 1991, Lukarevsky 1993). S. Biquand (*in litt.* 1993) reports predation on young camels near Medina in Saudi Arabia, and has found sheep and goat hair in leopard scats. There are numerous reports of local people going to extraordinary lengths to kill leopards reported in their vicinity, organizing hunting parties which do not return until the leopard is found and shot (Borner 1977, Habibi 1977, Gasperetti *et al.* 1986, Anon. 1989c, Harrison and Bates 1991, Anon. 1993f).

Action Planning

Projects 38, 39, and 40.

Sand cat, *Felis margarita* Loche, 1858

Other Names

Chat des sables (French); Sandkatze (German); gato de las arenas, gato del Sahara (Spanish); qit el remel, qit ramli, biss ramli (Arabic); hattul holot (Israel); sevin (Kazakh); peshaya koshka, barchannaya koshka (Russian); qareschtar, aghsheter (Tamahaq: central Sahara); mushuk (Uzbek).

Description and Behavior (Plate 3)

The sand cat is well adapted to the extremes of a desert environment and a psammophilic, or sand-dwelling, existence. It lives in areas far from water sources, and is able to satisfy its moisture requirements from its prey. Its coat is pale yellow to grey; the tail is ringed and there are dark horizontal bars on the legs. Sand cats are prolific diggers, an adaptation not only for hunting fossorial rodents but for constructing or improving upon the burrows in which they shelter, such as those dug by the sand fox (M. Abbadi *in litt.* 1993). Dragesco-Joffé (1993) notes that the sand cat's claws are not very sharp, as there is little opportunity to sharpen them in the desert, and that impressions of the claws are often visible in the tracks. The soles of the feet are covered with a thick layer of wiry black hair (Fig. 4), insulating the foot pads against extremes of heat and cold and allowing easier movement through sand. Daytime sand surface temperatures in the Sahara during the summer can reach 52° C (Yunker and Guirgis 1969). Day air temperatures range up to 58° C in the shade, but night temperatures are much lower, ranging down to -0.5° C (Cloudsley-Thompson 1984). In the northern parts of the sand cat's range, it snows in the winter, and temperatures drop as low as -25° C (Heptner and Sludskii 1972).

The sand cat is generally active only at night, according to the results of a radiotelemetry study in Israel (Abbadi 1992), tracks seen in the central Kara Kum Desert (Bilkevich 1934, cited in Ognev 1935), and activity patterns observed in captivity (Hemmer 1977). Sand cats have occasionally been observed above ground in day-

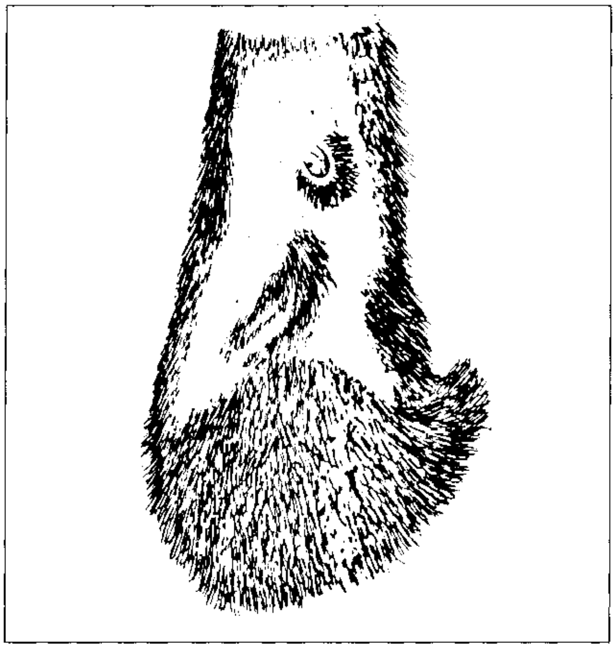

Figure 4. The underside of a sand cat's paw is protected from extreme desert temperatures by a thick covering of fur. The fur also helps spread the cat's weight so it can move more easily over shifting sands (Harrison 1968, Kitchener 1991).

light near their burrows (Lay *et al.* 1970, Abbadi 1992), lying on their backs in a posture which, in captivity, is regularly adopted at temperatures above 30° C and presumably helps to shed internal heat. In captivity, sand cats are very sensitive to humidity (Hemmer 1977), and it is interesting that during six months of radio-tracking, a sand cat was only observed resting outside its burrow in the daytime after several days of rain (Abbadi 1992).

The sand cat's ears are large and set widely apart and low on the sides of the head: this trait flattens the sand cat's profile hunting in barren areas, and may aid detection of movements of subterranean prey (Kingdon 1990), as well as protect the inner ears from wind-blown sand. The tympanic meati (passages from the external ears to the ear drums: up to 10.5 x 6.8 mm in diameter) and bullae (rounded bony capsules surrounding the middle and internal ears: 2.5-3.4 cm^3) are greatly enlarged relative to other small felids (Schauenberg 1974). A highly developed hearing capacity is important for locating prey which, in arid environments, is not only sparsely distributed, but also found underground.

There are few data on sand cat prey, in part because their habit of covering their scats with sand (Hemmer 1977) makes them difficult to locate (Abbadi 1992). Examination of 182 (Sapozhenkov 1961a) and 53 (Mambetzhumaev and Palianigazov 1968) stomachs and feces of sand cats from three central Asian deserts found the major prey species to be a diurnal species of the great gerbil. These gerbils were probably hunted in their burrows at night, which explains the sand cat's need for keen hearing. Hearing also plays an important role in intraspecific communication: sand cats make a short, rasping bark in connection with mating activity (Hemmer 1974a, Abbadi 1992. P. Quillen *in litt.* 1993). Their diet also includes birds, reptiles, and arthropods (Heptner and Sludskii 1972, Harrison and Bates 1991, Abbadi 1992).

Dragesco-Joffé (1993) says that the sand cat has a reputation amongst Saharan nomads for being a snake hunter, particularly of horned and sand vipers, which they stun with rapid blows to the head before dispatching with a neck bite. He also notes that sand cats will cover large kills with sand and return later to feed.

The first radio-telemetry study of the species, which monitored four cats for nine months in Israel's Aravah Depression (Abbadi 1992), found sand cats to be regular in their behavior. At nightfall, they took up a lookout position at their den opening, and surveyed the surroundings for about 15 minutes before leaving. They were active generally throughout the night, hunting and travelling an average of 5.4 km. Before retiring below ground at dawn, the same lookout position was adopted at the mouth of the burrow. Burrows were used interchangeably by different cats, and the animals did not change burrows during the day.

Weights of wild-caught adults from Turkmenistan range from 2.1-3.4 kg for males (n=12) and 1.4-3.1 kg for females (n=5) (Heptner 1970). Hemmer *et al.* (1976) present morphological data which suggest four distinct subspecies: Saharan (*margarita*), Arabian (*harrisoni*), central Asian (*thinobia*), and Pakistani (*scheffeli*). Karyotyping of a single specimen of each subspecies at Seattle's Woodland Park Zoo has yielded preliminary genetic evidence in support of these populations being separate (L. Werle, pers. comm., cited in Sausman 1991). However, the distribution patterns and habitat requirements of the sand cat are still poorly understood. Hemmer *et al.* (1976) note that there could be a number of isolated sub-populations in the Sahara, centered on the various giant discrete dune complexes (ergs).

Biology

Reproductive season: In the wild, births have been reported from January-April in the Sahara (Dragesco-Joffé 1993), in April in Turkmenistan (Ognev 1935, Heptner and Sludskii 1972) and September-October in Pakistan (Roberts 1977), but are not seasonal in captivity (Mellen 1989, Sausman 1991).

Estrus: (C) 5.25 ± 0.75 days (n=2).

Estrus cycle: (C) 46 days (n=1) (Mellen 1989).

Gestation: (C) 59-63 days (n=2: Scheffel and Hemmer 1974); 66-67 days (n=2: Mellen 1989).

Litter size: (C) 2.92 ± 0.21 (n=25: Mellen 1989); range up to five (P. Quillen *in litt.* 1993) and possibly eight (Hemmer 1977).

Age at independence: (W) Young sand cats grow rapidly (Heptner and Sludskii 1972), and are thought to become independent relatively early, perhaps at 6-8 months (Sausman 1991, H. Mendelssohn in litt.1993).

Age at sexual maturity: (C) 9 (P. Quillen *in litt.* 1993) to 14 months (Mellen 1989, Green 1991).

Longevity: (C) up to 13 years, but there is a high frequency of juvenile mortality in captivity (41% of 32 sand cats born in 1991: Sausman 1991).

Habitat and Distribution

Sand cats are found in both sandy and stony desert (Schauenberg 1974, Hemmer *et al.* 1976, Gasperetti *et al.* 1986, Harrison and Bates 1991, Abbadi 1992, Dragesco-Joffé 1993). For example, two specimens collected in eastern Egypt came from rather different habitat types. One was collected on a sandy plain near Lake Nasser with no vegetation in the immediate vicinity; the other was found in a rocky valley with widely scattered shrubs and trees (Goodman and Helmy 1986). Heptner and Sludskii

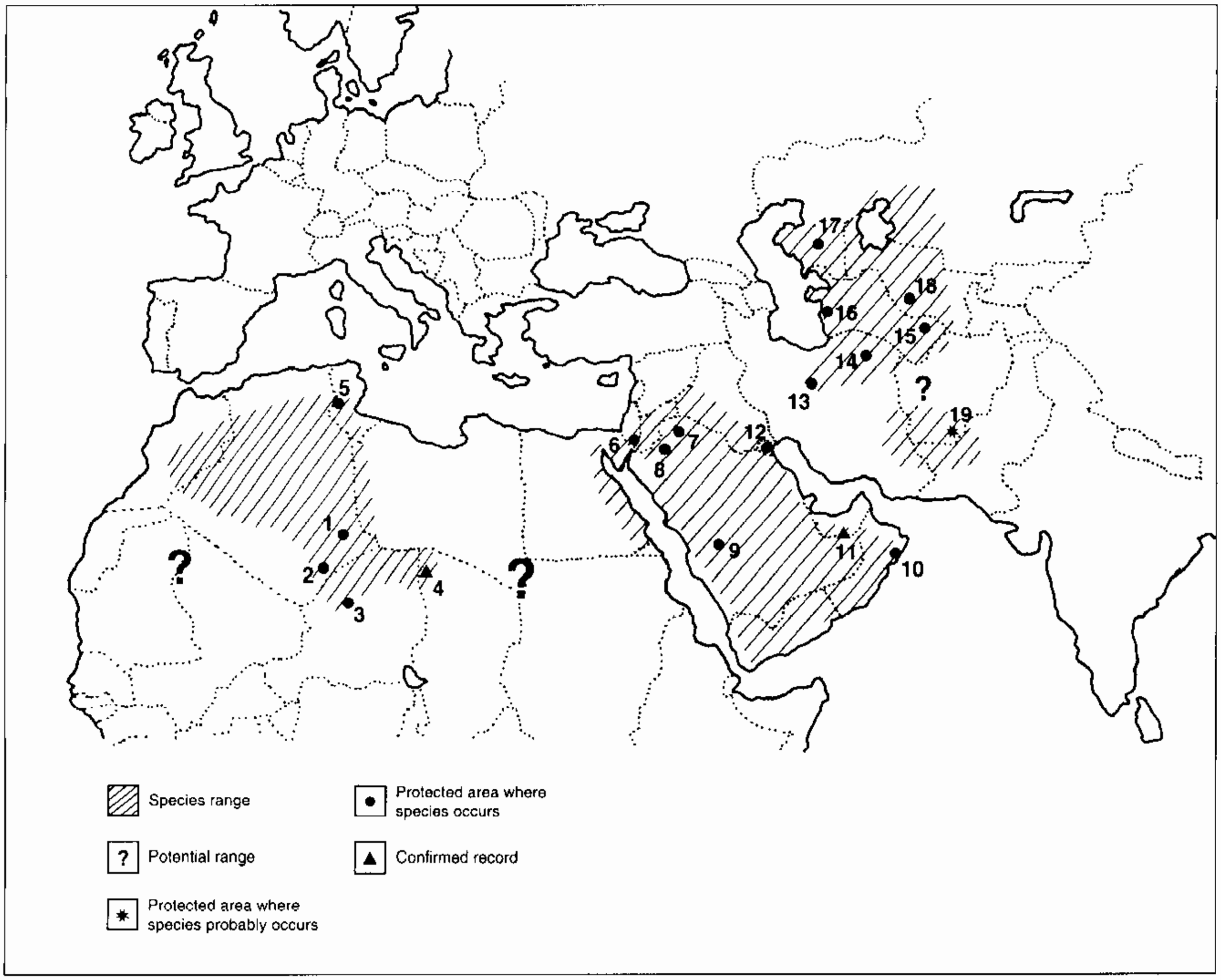

Figure 5. Distribution of the sand cat (*F. margarita*).
1. Tassili N'Ajjer II#; 2. Ahaggar II (Algeria); 3. Aïr & Ténéré VIII (Niger); 4. Specimen collected at Armumuit oasis, Adrar Souttouf Mts., Chad (Hemmer *et al.* 1976); 5. Djebel Bou-Hedma II* (Tunisia); 6. Hai Bar Yotvata IV (Israel); 7. Harrat al-Harrah IV; 8. Tubayq IV; 9. Mahazat as Sayed I (Saudi Arabia); 10. Wahibah Sands (proposed: Oman); 11. Specimens collected from the Al Liwa oasis, Empty Quarter, United Arab Emirates (M. Reza Khan *in litt.* 1993); 12 Jal az Zhor V (Kuwait); 13. Moteh V (M. Moinian, pers. comm.; cited in Groves 1990); 14. Touran V* complex (M. Karami, pers. comm.) (Iran); 15. Repetek I*; 16. Krasnovodsk I (Turkmenistan); 17. Ustyurt I (Kazakhstan); 18. Kyzylkum I (Uzbekistan); 19. Registan Desert Wildlife Mgt. Reserve (proposed: Afghanistan).

(1972) describe the sand cat in Turkmenistan as most abundant amidst extensive sand massifs, as in the central Karakum where compacted soils are generally absent. The micro-distribution of the small mammals which form the sand cat's prey is often clumped around vegetation and, especially during drought years, does not extend onto bare sand. However, following rains, the desert blooms and small mammals generally expand their ranges (Happold 1984). Sand cats occur only sparsely in the more clayey desert soils of the Ustyurt and Mangyshlak regions in the northern area between the Aral and Caspian Seas (Heptner and Sludskii 1972).

It is therefore likely that sand cats range throughout the sandy interior of the Sahara and the deserts of southwest Asia, but at present there are no specimens from the following countries: Mauritania, Western Sahara, Mali, Libya, Sudan, Syria, Iraq, Afghanistan, and Iran (although there is a report from the vicinity of Teheran [Weigel 1961], and two recent reports from the Moteh and Touran protected areas: Groves 1990, M. Karami, pers. comm. 1992]). No ecological explanation for these gaps in sand cat range has been put forward, and they are even more perplexing on a micro-scale. For example, sand cats are known from the Hoggar Mountains of southeastern Algeria (K. Kowalski in litt.; cited in de Smet 1989), the Aïr Mountains of northern Niger (Pocock 1938; J.

Newby, pers. comm. to K. de Smet), and the Tibesti Mountains of Chad (Hemmer *et al.* 1976), but not from the Adrar des Iforas massif of northeastern Mali (K. de Smet *in litt.* 1993). There is a record of the sand cat from the area between the Hoggar and Aïr mountains (Hemmer *et al.* 1976), so the absence from the Adrar des Iforas is suspect. Similarly, while the sand cat is known from the Aravah Depression of southern Israel, it has not been found in the Negev Desert sands just to the west (H. Mendelssohn *in litt.* 1993).

Figure 5 illustrates the probable distribution of the sand cat. The lack of records from Libya and southern Afghanistan is particularly puzzling (Hufnagl 1972, Schauenberg 1974, Hemmer *et al.* 1976), and will probably be proved false with time. In the early 20th century, confirmed records were available only from northwestern Africa, so that when the sand cat was found by Ognev (1926) in Turkmenistan, he described it as a new species. Arabia was the next area presumed to be a major gap in the sand cat's range, until a living specimen from the Arabian peninsula was acquired by the London Zoo (Haltenorth 1953, Hemmer 1974a, Hemmer *et al.* 1976). Finally, Hemmer *et al.* (1976) commented on the unusual lack of records for Egypt despite numerous zoological expeditions, but the first specimen was collected in that country as their article was going to press (Osborn and Helmy 1980, Goodman and Helmy 1986).

Population Status

Global: Category 4. Regional: Category 4. IUCN: Insufficiently Known; *scheffeli* (Pakistan) Endangered. Although the sand cat has been frequently described as rare, this may be a result of its harsh environment and nocturnal, subterranean, and secretive habits. For example, Abbadi (1992) describes the cats' "freezing" behavior when disturbed by people, and tendency to close their eyes against lights at night, making them very difficult to spot. Despite early reports that the sand cat population of Baluchistan's Chagai Desert was devastated by commercial collectors within 10 years after foreign collectors became aware of its existence (Roberts 1977, Hemmer 1977), more recent information indicates that the sand cat still occurs widely in the area (P. Paillat, pers. comm. to S. Biquand 1993).

M. Abbadi (*in litt.* 1993), who carried out the first radio-telemetry study of the sand cat in Israel, knew of 22 individuals within his 100 km^2 study area. The home range of one adult male was estimated at 16 km^2, and overlapped with those of neighboring males (Abbadi 1992).

Protection Status

CITES Appendix II. National legislation: lacking information. Hunting prohibited: Algeria, Iran, Israel, Kazakhstan, Mauritania, Niger, Pakistan, Tunisia. No legal protection: Egypt, Mali, Morocco, Oman, Saudi Arabia, United Arab Emirates. No information: Iraq, Jordan, Kazakhstan, Libya, Qatar, Tajikistan, Turkmenistan, Uzbekistan, Western Sahara, Yemen (IUCN Environmental Law Centre 1986), Nichols *et al.* 1991, Belousova 1993; T. Anada, R. Daly, J. Gasperetti, I. Nader, M. Reza Khan *in litt.* 1993).

Principal Threats

Although the current lack of knowledge about the species' status and biology makes an assessment premature, the sand cat appears to be one of the least threatened felid species. Its preferred habitat is not being lost or degraded; if so-called "desertification" is a real phenomenon (Stevens 1994), it should actually benefit the species. Heptner and Sludskii (1972) were of the opinion that sand cat populations in the central Asian deserts were stable and not threatened, despite harvests at that time of the order of 100-200 skins per year. De Smet (1989) reported that oasis residents in Algeria did not consider it a threat to poultry, and did not trap it to sell as a pet. On the other hand, Toubou nomads living northwest of Lake Chad consider the sand cat a frequent chicken thief, which readily enters their camps in the evenings, but they do not generally retaliate due to traditional religious respect for the small cats because of their association with the Prophet Mohammed (Dragesco-Joffé 1993).

Action Planning

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Caracal, *Caracal caracal* (Schreber, 1776)

Other Names

Desert lynx (English); caracal (French); caracal, Wüstenluchs (German); caracal, lince africano (Spanish); ajal, anaq al ardh, washag (Arabic); warsal, bousboela, mousch, nouadhrar, aousak (Berber: Algeria); psk qarh qol (Dari: Afghanistan); harnotro [killer of blackbuck] (Kutchi dialect of Gujarati: India); siagosh (Persian); karakal (Russian); itfah (Saudi Arabia); orei, ngam ouidenanga (Tamacheq, Toubou [Touareg]: central Sahara); karakulak, step vasagi (Turkish); karakulak (Uzbek).

Description and Behavior (Plate 3)

Like cheetahs, caracals were trained to hunt for the nobility in India (Sterndale 1884, Sharma and Sankhala 1984). In general, caracals from this region are somewhat smaller than those of sub-Saharan Africa, with paler fur in the arid regions (Harrison and Bates 1991, K. de Smet *in litt.* 1993). Heptner and Sludskii (1972) remark that the pelage of desert caracals bears a surprising resemblance in color to that of the goitred gazelle. They also note that Turkmen caracals have tufts of stiff hairs on the paws like the sand cat. Weisbein (in Mendelssohn 1989) also reports the presence of a dark form in 5-10% of the caracal population in central Israel, with adults grey and young kittens almost black. The average weight of male carcals in Israel is 9.8 ± 1.8 kg (n=6); females weigh 6.2 ± 0.7 kg (n=5) and are markedly smaller than males (Weisbein 1989).

Diet is similar to that reported from sub-Saharan Africa, consisting mainly of small mammals and birds (Ognev 1935, Roberts 1977, Sharma and Sankhala 1984). Through scat analysis, prey remains, stomach contents and direct observation, Weisbein (1989) determined that the diet of caracals in an irrigated agricultural area of Israel consisted of 62% mammals, 24% birds, 6.1% reptiles, and 1.4% insects. In the deserts of Turkmenistan, tolai hares were the most important prey species (Sapozhenkov 1962, Ishadov 1983).

Caracals occasionally tackle larger prey, including adult goitred gazelle (Heptner and Sludskii 1972). Harrison and Bates (1991) note a report from southern Arabia of a caracal killed by a wounded oryx it had attacked. K. de Smet (*in litt.* 1993) found the tracks of a caracal pursuing a dorcas gazelle in Algeria, and caracals to the northwest of Lake Chad are reputed to hunt these gazelles, hence the local Toubou name "gazelle cat" (Dragesco-Joffé 1993). Roberts (1977) notes a record of a caracal stalking a group of feeding urial in daylight in Pakistan. Caracals have also been observed to feed on carrion: Mendelssohn (*in litt.* 1993) describes garbage dumps at poultry farms as rich food sources, and once saw a caracal leap onto a cart of dead turkeys and select one. A. Livne (pers. comm. cited in Skinner 1979) observed a caracal chase two sub-adult striped hyaenas from a donkey carcass.

Weisbein's (1989) radiotelemetry study in Israel found that caracals rested during the day in dense vegetation or rock crevices, and were generally active from dusk to dawn and in early morning. Elsewhere, burrows were also used for shelter (Heptner and Sludskii 1972, Roberts 1977). Males travelled an average of 10.4 ± 5.2 km (n=40) per 24-hour period, while females travelled 6.6 ± 4.1 km (n=37) (Weisbein 1989). Nocturnal travels up to 20 km have been documented by following tracks in the Karakum desert of Turkmenistan (Sapozhenkov 1960).

Biology

Reproductive season: (W) Year-round (Roberts 1977, Sharma and Sankhala 1984, Weisbein 1989); in the Sahara, breeding is reported to occur primarily in mid-winter (Jan) (Dragesco-Joffé 1993); in Turkmenistan, kittens have been found in April-May (Heptner and Sludskii 1972).

Estrus: (W) 5-6 days (n=3). Females copulate with several males in a "pecking order" which is related to the age and size of the male. One female was found to have mated with three different males during every estrus period, each time the same individuals in the same sequence (Weisbein 1989).

Age at independence: (W) 9-10 months (n=1; Weisbein 1989).

Habitat and Distribution

The caracal is widely distributed through the region, absent only from true desert (Fig. 6). In north Africa, it is common in the humid forest zone of the northern coastal regions, and is also found in the Saharan mountain ranges (K. de Smet *in litt.* 1993) and semi-arid woodlands (Dragesco-Joffé (1993). In microhabitat preference, it is typically associated with either well-vegetated or rocky areas (Heptner and Sludskii 1972, Gasperetti *et al.* 1986, Weisbein 1989, A. Johnsingh *in litt.* 1991, Dragesco-Joffé 1993), which provide cover for hunting as well as shelter. It is often found near water points (Heptner and Sludskii 1972; S. Biquand, H. Mendelssohn *in litt.* 1993), but is apparently capable of satisfying its moisture requirements from its prey (Dragesco-Joffé 1993, J. Gasperetti *in litt.* 1993).

Population Status

Global: Category 5b. Regional: Category 5a(A). IUCN: Turkmenian caracal Rare. The regional Red Data Books of the former U.S.S.R. describe the caracal as rare, with the largest population found in Turkmenistan (estimated at 250-300 for the country: Belousova 1993). In Kazakhstan, the northernmost limit of its range, harsh winters are the limiting factor (Neronov and Bobrov 1991). Small populations occur in Uzbekistan along the Amu-Darya River (Heptner and Sludskii 1972). The caracal is described as rare in India, the eastern limit of its range (Pocock 1939a, Sharma and Sankhala 1984, R.S. Bhadauria *in litt.* 1991). Overall, and especially compared to the larger cats, the caracal is relatively secure, still widespread, and occasionally common.

The only study of a caracal population in the region was carried out in an agricultural area in Israel's Negev Desert (Weisbein 1989). Despite a rich prey base supported by irrigation, home ranges were substantially larger than found in South Africa (where the only other radiotelemetry studies have been carried out). Male home ranges averaged 221 ± 132 km^2 (n=5), and those of females 57 ± 55 km^2 (n=4). Home range size was positively correlated with body weight, and negatively correlated with prey availability. Male home ranges overlapped substantially (50%), and typically included those of several females. Two dispersals

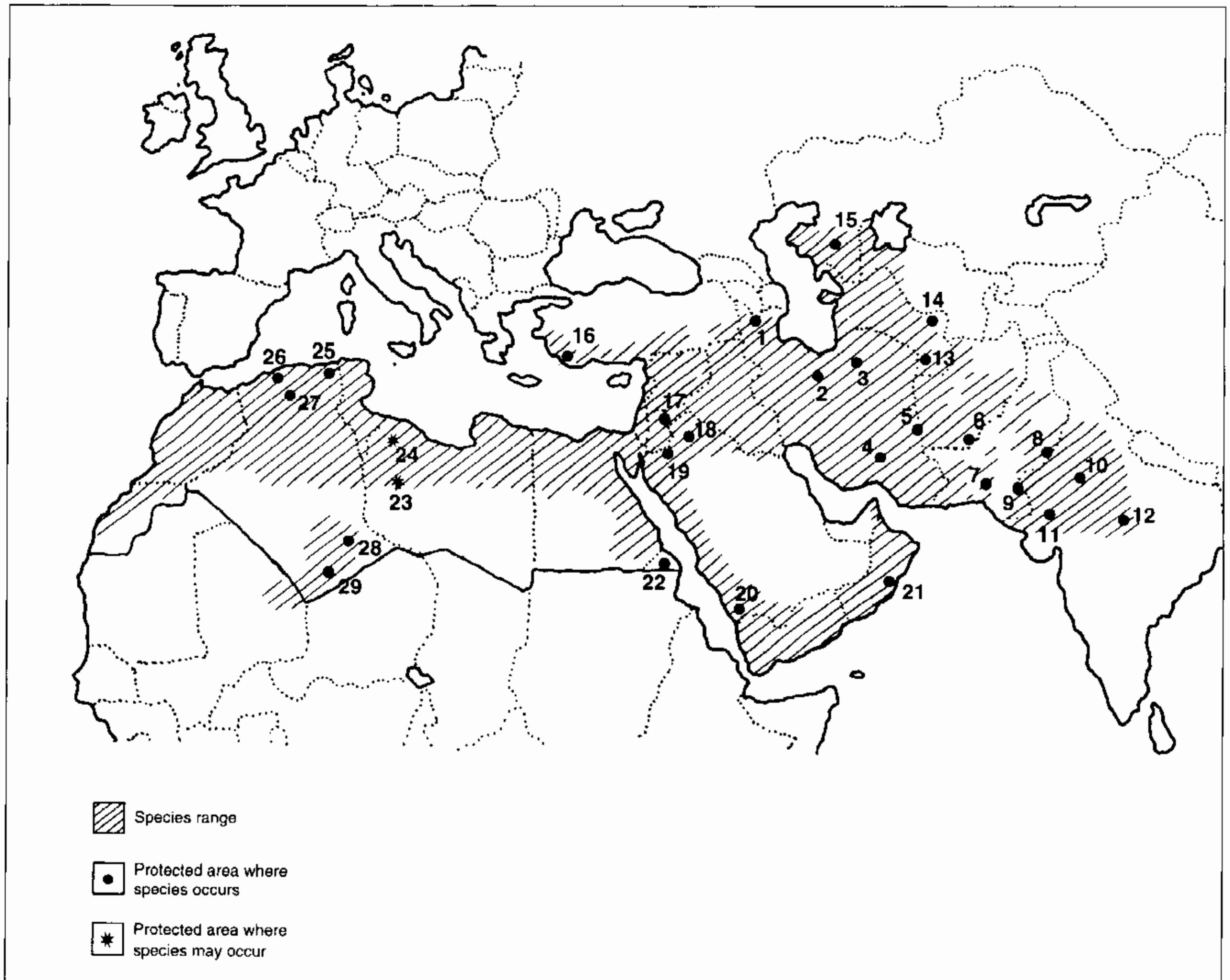

Figure 6. Distribution of the caracal (*C. caracal*) in north Africa and southwest Asia.
1. Kiamaky I; 2. Kavir II* complex; 3. Touran V* complex; 4. Khab-o-Rouchon I; 5. Hamoun V (Iran); 6. Registan Desert Wildlife Management Reserve (proposed: Afghanistan); 7. Kirthar II complex; 8. Lal Suhanra V*; 9. Cholistan IV (Pakistan); 10. Sariska II complex; 11. Dhrangadhra (Wild Ass) IV; 12. Ranthambore II (India); 13. Badkhyz I; 14. Repetek I* (Turkmenistan); 15. Ustyurt I (Kazakhstan); 16. Dilek Yarimadisi II (Turkey); 17. Azraq Desert IV (Jordan); 18. Harrat al-Harrah IV; 19. Tubayq IV; 20. Asir V (Saudi Arabia); 21. Jiddat al-Harasis VI (Oman); 22. Gebel Elba IV (Egypt & Sudan); 23. Zellaf IV; 24. Nefhusa IV (Libya); 25. El Kala V; 26. Chrea II; 27. Djelfa IV; 28. Tassili N'Ajjer II#; 29. Ahaggar II (Algeria).

were observed: a male migrated 60-90 km south before establishing a home range, whereas a female remained in the vicinity of her natal range, with her range partly overlapping that of her mother. Twenty caracals, several of them transients, were found to utilize an area of 100 km^2 (with some ranging outside this area), making for a relatively high local density despite the large home ranges.

Protection Status

Populations of Asian range states: CITES Appendix I; African range states CITES Appendix II. National legislation: lacking information. Hunting prohibited: Algeria, India, Iran, Israel, Kazakhstan, Morocco, Pakistan, Tajikistan, Tunisia, Turkey, Turkmenistan, Uzbekistan. No legal protection: Egypt, Lebanon, Oman, Saudi Arabia, United Arab Emirates. No information: Afghanistan, Iraq, Jordan, Kuwait, Libya, Qatar, Syria, Western Sahara (Nichols *et al.* 1990, IUCN Environmental Law Centre 1986, Belousova 1993; R. Daly, I. Nader, M. Reza Khan, A. Serhal, S. Umar *in litt.* 1993).

Principal Threats

Caracals prey mainly on small mammals, which are generally not adversely affected by human settlement (Le Berre 1991). However, caracals are capable of taking small domestic livestock, and surplus killing can result when the animals are attacked in enclosed spaces (Weisbein and Mendelssohn 1990). Such incidents could lead to vigorous persecution by pastoralists. Several authors have reported caracals to be susceptible to trapping with fresh bait (Roberts 1977, Gasperetti *et al.* 1986). However, Saharan nomadic pastoralists interviewed by Dragesco-Joffé (1993) stated that problem caracals were difficult to eliminate because they did not take bait, and must be chased and treed by hounds. Weisbein (1989) suggests that caracals are more disposed towards taking easily acquired prey (e.g. bait, carrion and domestic animals) in the colder months of winter as an energy saving strategy. His work indicates that, in the absence of heavy persecution, caracals can adapt well to living in settled areas in the region.

Action Planning

Project 42.

Part I
Species Accounts

Chapter 3
Tropical Asia

Box 1
Vulnerability Index to Species of the Region (in order of vulnerability)

Species	Habitat Association St [Mar] (Tot) Score	Geog. Range (10^6 km²)	Score	Body Size Score	Total Score	Ranking
Tiger, *P. tigris**	I: 6 [3] (9) 0	S: 1.99	-1	L -1	-2	1(A)
Bornean bay cat, *C. badia**	N: 2 [0] (2) -1	R: 0.51	-2	S +1	-2	1
Clouded leopard, *N. nebulosa**	I: 4 [4] (8) 0	S: 2.79	-1	M 0	-1	2(A)
Asiatic golden cat, *C. temmincki**	I: 5 [3] (8) 0	S: 2.66	-1	M 0	-1	2
Flat-headed cat, *P. planiceps**	N: 3 [0] (3) -1	S: 1.18	-1	S +1	-1	2
Rusty-spotted cat, *P. rubiginosus**	I: 7 [0] (7) 0	R: 0.78	-2	S +1	-1	2
Fishing cat, *P. viverrinus**	I: 5 [1] (6) 0	S: 2.33	-1	M 0	-1	2
Marbled cat, *P. marmorata**	N: 3 [1] (4) -1	S: 2.42	-1	S +1	-1	2
Leopard, *P. pardus*	B: 6 [5] (11) +1	I: 4.84	0	L -1	0	3(A)
Jungle cat, *F. chaus*	B: 6 [5] (11) +1	S: 2.69	-1	S +1	+1	4
Leopard cat, *P. bengalensis**	B: 7 [5] (12) +1	W: 8.66	+1	S +1	+3	5

Key:

* All or most of this species' range lies within the region

Habitat Association
St = number of strong + significant habitats
N = Narrow (-1); I = Intermediate (0); B = Broad (+1)
[Mar] = number of marginal habitats
(Tot) = total number of habitats

Geographic Range (in millions of km²)
R = Restricted (-2); S = Small (-1); M = Medium (0); W = Wide (+1)

Body Size
L = Large (-1); M = Medium (0); S = Small (+1)

(A) = Actively threatened

Regional Criteria
Habitat association: Narrow = 2-4 habitat types; Intermediate = 6-9 habitat types; Broad = 11-12 habitat types.
Geographic range: Restricted = ≤1 million km²; Small = 2-3 million km²; Medium = 4-5 million km²; Wide = 8-9 million km².
Body size: Large = 35-135 kg; Medium = 7-20 kg; Small = ≤6.5 kg

See the Introduction to the Species Accounts for explanation of the vulnerability ranking system (pp. 2-6).

Tiger, *Panthera tigris* (Linnaeus, 1758)

Other Names

Tigre (French); tiger (German); tigre (Spanish); lao hu (Chinese); bagh (Hindi, Bengali: India, Bangladesh); rimau, harimau (Indonesia, Malaysia); klaa thom (Khmer); sua khong, sua lay (Laos); kaduva (Malayalam: India); sher (Persian); tigr (Russian); pedda puli (Telugu, India); seua (Thailand); tag (Tibetan); amba darla (Udege: Amur River region, Russia).

Description and Behavior (Plate 7)

Largest of the extant cats and comparable in size to the biggest of the fossil felids (Mazák 1981), the tiger is also one of the best-known large mammals. The reddish-orange to yellow-ochre coat with black stripes and white belly is immediately recognizable. The tiger is generally divided into the following subspecies (Mazák 1981):

- *P. t. tigris* (Linnaeus, 1758). Bengal tiger. Indian subcontinent.
- *P. t. virgata* (Illiger, 1815). Caspian tiger. Turkey through central and west Asia.
- *P. t. altaica* (Temminck, 1844). Amur tiger. Amur River region of Russia and China, and North Korea.
- *P. t. sondaica* (Temminck, 1844). Javan tiger. Java, Indonesia.
- *P. t. amoyensis* (Hilzheimer, 1905). South China tiger. South central China.
- *P. t. balica* (Schwarz, 1912). Bali tiger. Bali, Indonesia.
- *P. t. sumatrae* Pocock, 1929. Sumatran tiger. Sumatra, Indonesia.
- *P. t. corbetti* Mazák, 1968. Indo-Chinese tiger. Continental southeast Asia.

Three races—the Caspian (*virgata*), Bali (*balica*), and Javan (*sondaica*) tigers—have become extinct since the 1950s. Tiger subspecies have been evaluated using both morphological and molecular methodologies (Hemmer 1978b, 1987; Mazák 1981, 1983; Herrington 1987). Herrington (1987) was able to distinguish six subspecies reliably based on skull measurements (no Caspian or Bali tigers were analyzed), although she noted that there was considerable overlap of *tigris* and *corbetti*, and some overlap of *corbetti* and *sumatrae*. Tiger subspecies are now being re-evaluated using the latest techniques of molecular analysis, with samples being collected from wild tigers in the Russian Far East and India, and from captive Sumatran and South China tigers of known origin and bloodline (S. O'Brien, pers. comm. 1994).

Hemmer (1987) and Mazák (1983) place the origin of the tiger in east Asia, from where two major dispersals took place approximately two million years ago. To the northwest, tigers migrated through woodlands and along river systems into southwest Asia. To the south and southwest, tigers moved through continental southeast Asia, some crossing to the Indonesian islands, and others finally reaching India. Herrington (1987) concurs that the South China tiger may be regarded as a relict population of the "stem" tiger, living in the probable area of origin of the species. It has distinctive primitive skull morphology, including a shortened cranial region and close-set, more forward-facing eye sockets.

Stripe patterns differ among individual tigers and from one side of the cat's body to the other. The stripes vary in number, as well as width and propensity to split and run to spots. The dark lines above the eyes tend to be symmetrical, but the marks on the sides of the face can be different. No two tigers have the same markings (Sunquist and Sunquist 1991). Males have a prominent ruff, which is especially marked in the Sumatran tiger.

White tigers have existed in the wild in India. A white male cub taken in Rewa, central India, in 1951, was the last record. Named Mohan, this tiger became the progenitor of most white tigers now in captivity when bred with a daughter, proving that the albinism is the result of a recessive gene. White tigers have brown stripes on an off-white background and ice-blue eyes (Maruska *et al.* 1987)

Black tigers have been reported occasionally (Burton 1933, Perry 1964, Guggisberg 1975, Mazák 1981), but the only physical evidence rests with a skin recovered from illegal traders in Delhi in October 1992, which has deep black on the top of the head and back extending down the flanks to end in stripes (P. Jackson, pers.comm.). It is not true melanism, which is found in leopards, jaguars, and many other cat species, where the entire pelage is black, but may be an expression of the agouti gene which causes merging of stripes (L. Lyons *in litt.* 1993). Specimens with just a few, very broad stripes have been photographed in Kanha NP, India (R. Bedi *in litt.*).

The winter and summer fur of the Amur tiger, as well as of the extinct tigers of Turkestan and the Caucasus, differs sharply. The hairs in winter grow dense and long, giving some animals a plush or even shaggy appearance. The winter coat is generally paler, or more ochraceous, than in summer (Heptner and Sludskii 1972).

While tigers are usually solitary, except for females with cubs, they are not anti-social. Males associate with females for breeding and have been observed with females and cubs when feeding or resting (Schaller 1967, McDougal 1977, Sankhala 1978, Sunquist 1981, Thapar 1986, 1989). Bragin (1986) quoted reports of tigers socializing and travelling in groups. A mature male in Kanha National Park, India, was greeted by a female and cubs and by a sub-adult male, thought to be from a previ-

Table 1
Size Variation in Tiger Subspecies (Adult Specimens) (Mazák 1981)

Subspecies	Weight (kg)		Total length (m)[1]		Skull length (mm)	
	Male	Female	Male	Female	Male	Female
tigris	180 - 258	100 - 160	2.7 - 3.1	2.4 - 2.65	329 - 378	275 - 311
virgata	170 - 240	85 - 135	2.7 - 2.95	2.4 - 2.6	316 - 369	268 - 305
altaica	180 - 306	100 - 167	2.7 - 3.3	2.4 - 2.75	341 - 383	279 - 318
sondaica	100 - 141	75 - 115	2.48	—	306 - 349	270 - 292
amoyensis	130 - 175	100 - 115	2.3 - 2.65	2.2 - 2.4	318 - 343	273 - 301
balica	90 - 100	65 - 80	2.2 - 2.3	1.9 - 2.1	295 - 298	263 - 269
sumatrae	100 - 140	75 - 110	2.2 - 2.55	2.15 - 2.3	295 - 335	263 - 294
corbetti	150 - 195	100 - 130	2.55 - 2.85	2.3 - 2.55	319 - 365	279 - 302

[1] Measured "between pegs."

ous litter. They moved away together (Wright 1989). However, males may kill cubs fathered by other males: Smith and McDougal (1991) found that the major cause of death of tiger cubs in Nepal's Royal Chitwan National Park was infanticide.

Unlike many other cat species, tigers readily enter water. During hot seasons they will lie half-submerged in lakes and ponds during the heat of the day. In the Ganges-Brahmaputra mangrove delta region of the Sundarbans in India and Bangladesh, they constantly swim creeks and across broad rivers. Garga (1948) records tigers swimming a 29 km wide river in the Sundarbans and mentions the possibility that one may have swum 56 km. The Sundarbans tigers have taken people out of boats (Jackson 1991a). Burton (1933) records a tiger swimming eight km from the Malaysian mainland to Penang Island; Heptner and Sludskii (1972) report the same distances swum across the Amu-Darya and Amur rivers in the Caspian area and the Russian Far East respectively. In India's Ranthambhore Tiger Reserve, tigers have charged into lakes to kill sambar deer, so that both animals were momentarily submerged. Crocodiles have been killed and eaten by tigers in the area (V. Thapar, pers. comm.).

Tigers hunt mainly between dusk and dawn, but in the secure conditions of Ranthambhore in the 1980s, tigers frequently hunted during the day (Thapar 1992). The principal prey across their range consists of various species of deer and wild pigs, but U. Karanth (pers. comm.) states that in India's Nagarhole National Park, gaur are the main prey, including bulls weighing up to 1,000 kg. Tigers will also attack young of elephants and rhinos, and take smaller species, including monkeys, birds, reptiles, and fish. Tigers sometimes kill and eat leopards and their own kind, as well as other carnivores, including bears, weighing up to 170 kg, which they have attacked in their winter dens (Hepter and Sludskii 1972). They readily eat carrion (Schaller 1967).

Tigers usually attack large prey with a stalk from the rear, ending with a rush and, sometimes, a spring to bring down the prey. When seizing and killing prey, the tiger's main target is the neck, either the nape or the throat. The part seized depends on several factors, such as the size of the prey; the size of the tiger; whether the attack is from front, rear or side; and the reactive movements of the prey. Most observations have been of attacks on tethered, young male buffaloes, whose movements are handicapped. There have been relatively few observations of attacks on free-ranging wild animals. Attack and killing methods are described by Brander (1923), Champion (1927), Burton (1933), Corbett (1957), Schaller (1967), McDougal (1977), Thapar (1986), Karanth 1993, Sankhala (1993), and Seidensticker and McDougal (1993). Schaller (1967) noted that adult tigers appeared to be very cautious, and attacked only when the danger of injury was minimal. He states that a tiger characteristically grasps the throat after felling its prey, holding on until the animal dies from suffocation. The throat hold protects the tiger from horns, antlers, and hooves and prevents the prey from regaining its feet. Sankhala (1993) states that tigers prefer to bite the back of the neck, as close as possible to the skull, killing the victim by fracturing the vertebrae and compressing the spinal chord. Larger animals, however, are generally killed with a throat bite. For example, Karanth (1993) examined 181 tiger kills and found that most large prey, such as sambar and gaur, were killed by throat bites. The prey is then usually dragged into cover, tigers displaying their great strength in dragging, even lifting, heavy carcasses. Pocock (1939a) cites an instance in Burma of a tiger dragging the carcass of a gaur that 13 men could not move.

A tiger eats 18-40 kg of meat at a time (Baikov 1925, Locke 1954, Schaller 1967) beginning from the rump. If undisturbed, it returns to its kill for 3-6 days to feed until little remains (Karanth 1993a). Large prey is taken about once a week. Sunquist (1981) estimated frequency of killing by females without cubs at once every 8-8.5 days in Chitwan. Although highly skilled hunters, tigers are often unsuccessful. They seldom make the effort to press home a failing attack, but Rice (1986) once observed a tiger pursue a wounded sambar for more than two kilometers for just over two hours in southern India. Schaller (1967) observed 12 complete stalks, of which only one was successful, and suggested that it was probable that only one in 20 attacks succeeded. According to V. Thapar (pers. comm.), one in 10 attacks are successful in Ranthambore, with its high density of prey.

Cooperative hunting has been observed. Pocock (1939a) said that couples and family groups hunted together, but gave no references. Thapar (1986) observed several instances in Ranthambhore. A group of two males and three females, possibly a family, behaved like lions, taking up positions round a lake where deer congregated and driving a target animal from one to the other. Corbett (1953) mentions villagers' reports of two tigers, attacking in concert, killing a large tusker elephant.

Although lions and leopards also kill humans, tigers have the greatest reputation as man-eaters, especially in India. The history of man-eaters (the term is loosely used to include fatal attacks due to some form of provocation) is reviewed by McDougal (1987). He quotes average fatalities due to tigers at 851 a year between 1902 and 1910, and 1,603 in 1922 alone. The Champawat tiger is said to have killed 434 people in Nepal and India before it was shot (Corbett 1952). However, in recent times, with greatly reduced numbers of tigers, attacks on people have been relatively rare, except in the Sundarbans mangrove forest fringing the Bay of Bengal in India and Bangladesh. The recent annual toll of people in the Indian Sundarbans tiger reserve has fluctuated between 66 in 1975-1976, 15 in 1989, and 42 in 1992 (K. Chakrabarty, S.C. Dey, pers. comm.). Most deaths have been of fisherfolk, wood-cutters, and honey collectors entering the reserve. The high 1992 figure is attributed to illegal entry by people, including young children, seeking to benefit from lucrative prawn harvesting (S.C. Dey, pers. comm. 1992). Earlier, management measures, including the use of human face masks on the back of the head to deter tigers (which usually attack from the rear) appeared to be reducing the toll (Rishi 1988, P. Sanyal, pers. comm. 1990).

Since 1978, over 200 people have been killed in the vicinity of India's Dudhwa National Park, near southwestern Nepal. The problem is attributed especially to sugar cane cultivation right to the edge of the park. The cane fields provide good cover for tigers, which then come into contact with agriculturists. Many deaths arise from accidental confrontations in which the tiger makes a defensive attack.

The Sundarbans tigers have had a reputation as man-eaters since at least the 17th century (Bernier 1670), but elsewhere man-eating is usually the result of a tiger's incapacity, through age or injury, to catch normal prey. A chance encounter in which such a tiger kills someone in a defensive reaction and feeds on the body may lead it to target people as easy prey. A man-eating tigress may introduce her cubs to human prey. But deaths and injuries caused by surprised tigers or a tigress defending her cubs from intrusion do not usually lead to man-eating. Schaller (1967) agrees with the view of Corbett (1957): "Tigers, except when wounded or man-eaters, are on the whole very good tempered. If warnings (growls, rushes, and roars) are disregarded, the blame for any injury inflicted rests entirely with the intruder." See Part II, Chapter 2 for more discussion of man-eating.

Biology

Reproductive season: (W) Mating takes place year-round, but most frequently from end November to early April (Mazák 1981); Manchuria: December-February (Ognev 1935, Baikov 1936); India: November-April (Singh 1959, Sankhala 1967, Schaller 1967, Sankhala 1978). In Nepal, young born throughout the year in Chitwan NP, with a birth peak from May-July (Smith and McDougal 1991).

Estrus: (C) mean seven days (Sunquist 1981).

Estrus cycle: (W) 15-20 days in Rajasthan, India (Sankhala 1967); this is supported by observations of male-female association in Chitwan (Smith 1978, Sunquist 1981). (C) 46-52 days (Sadleir 1966); 34-61 days (Sankhala 1978); 51.9 days in Basel Zoo (Sankhala 1978). If a litter is lost, estrus occurs within a few weeks (mean 17 days, range 10-39, n=3: Sankhala 1978).

Gestation: (C) about 103 days (Sankhala 1978, Sunquist and Sunquist 1991, Kitchener 1991).

Litter size: (W) mean 2.98 (range 2-5, n=49 in Chitwan NP: Smith and McDougal 1991); range 1-7 (Brander 1923). Observations of females with cubs indicate that 2-3 is most common (Sankhala 1978). (C) mean 2.9 (n=49 litters, range up to 6, in Indian zoos: Sankhala 1978).

Age at independence: (W) 18-28 months (male and female: Smith 1984).

Juvenile mortality: (W) In Chitwan, Smith and McDougal (1991) found first-year cub mortality to be 34% (n=144 cubs), of which 73% was whole litter loss due to causes including fire, floods, and infanticide. Mortality in the second year of life was 17% (n=94), of which only 29% was whole litter loss. Infanticide was overall the most common cause of cub death.

Age at first reproduction: (W) females 3.4 years (n=5), males 4.8 years, range 3.4-6.8 years (Smith and McDougal 1991); (C) 3-6 years (Sankhala 1967, Schaller 1967).

Interbirth interval: (W) 20-24 months (n=7: Smith and McDougal 1991) - 2-2 1/2 years (Sunquist 1981); but in two cases when litters were lost in the first two weeks the interval was eight months (Smith and McDougal 1991).

Age at last reproduction: (C) 14 years (Crandall 1964, Kleiman 1974).

Lifetime reproduction: Data collected over nearly 20 years by the long-term tiger population monitoring project at Nepal's Chitwan National Park enabled Smith and McDougal (1991) to present pioneering data on lifetime reproduction in a wild cat species, a critical component of population viability models. They found the average reproductive life span of Chitwan tigers to be 6.1 years for females (n=12; range up to 12.5 years); and just 2.8 years for males (range seven months to six years). For females, the mean number of offspring surviving to dispersal was estimated at 4.54 (variance 11.48), and the average number of offspring eventually incorporated into the breeding population was just 2.0 (variance 3.26). For males, an average of 5.83 of their offspring survived to dispersal (variance 49.97), and 1.99 were incorporated into the breeding population (variance 6.97).

Longevity: (W) one female was killed in Chitwan when at least 15.5 years old (McDougal 1991); (C) up to 26 years (Jones 1977).

Habitat and Distribution

The tiger is found in a variety of habitats: from the tropical evergreen and deciduous forests of southern Asia to the coniferous, scrub oak, and birch woodlands of Siberia. It also thrives in the mangrove swamps of the Sunderbans, the dry thorn forests of northwestern India, and the tall grass jungles at the foot of Himalayas. Tigers are found in the Himalayan valleys, and tracks have been recorded in winter snow at 3,000 metres (Prater 1971). The extinct Caspian tiger frequented seasonally flooded riverine land known as *tugai*, consisting of trees, shrubs, and dense stands of tall reeds and grass up to six metres in height. (When hunting in these reed thickets, tigers sometimes reared up on their hind legs or leaped upward in order to see their surroundings: Heptner and Sludskii 1972.) The tiger's habitat requirements can be summarized as: some form of dense vegetative cover, sufficient large ungulate prey (Sunquist and Sunquist 1989), and access to water.

The geographic distribution of the tiger once extended across Asia from eastern Turkey to the Sea of Okhotsk (Fig. 1). However, its range has been greatly reduced in recent times. Currently, tigers survive only in scattered populations from India to Vietnam, and in Sumatra, China, and the Russian Far East (Fig. 2).

Population Status

Global: Category 2(A). Regional: Category 1(A). IUCN: Endangered. There may have been 100,000 tigers at the end of the 19th century; a recent mail survey and literature review of the status of the tiger for CITES (Jackson 1993a) concluded that the maximum number is no more than 7,700. Including "unofficial" institutions such as circuses, there might be more tigers in captivity in the world now than in the wild.

Of all the range states, India has by far the largest number of tigers. Gee (1964) suggested that it was possible that there were 40,000 tigers in India early in this century, compared to about 4,000 by the time he wrote. In 1972, an official census found positive evidence of fewer than 2,000 tigers in India (Govt. of India 1972), located in four main areas of forest: the foot of the Himalayas in north and northeastern India, the forests of central and eastern India, and a narrow strip paralleling the southwestern coast. An intensive conservation program, Project Tiger, was started shortly thereafter (for more information about Project Tiger, see Part II, Chapter 1), and its 1989 census estimated numbers nationwide at 4,334. However, there has been widespread poaching in the early 1990s, and the most recent 1993 census estimates 3,750 tigers (including, as with the previous total, sub-adults) (Ghosh 1994).

However, it has been officially stated that the population estimates of predators and prey base in India suffer from large margins of error (Govt. of India 1993). Karanth (1987, 1993b) is highly critical of the methodology of pugmark identification and counting (see Part II Chapter 3). Unofficial estimates in 1993 by experienced tiger managers ranged from 2,000 to 4,500 (Jackson 1993a, V. Thapar, pers. comm.). Including a few hundred tigers in Nepal (late 1993 estimate 250: C. McDougal, pers. comm.), Bhutan, Bangladesh, and western Myanmar, the total population of Bengal tigers (*P.t. tigris*) is probably not more than 4,500 (Jackson 1993a).

Estimates of the number of Indochinese tigers (*P.t. corbetti*), found from eastern Burma through continental southeast Asia to Vietnam, range from 1,050 to 1,750 (Jackson 1993a) but there are few data. Rabinowitz (1993) surveyed major protected areas in Thailand between 1987-1991, and estimated the number of tigers in that country at 250, in sharp contrast to official government estimates of 450-600 (Anon. 1994c). The Malaysian Wildlife Department estimated 600-650 tigers in the Peninsula (Anon. 1994c).

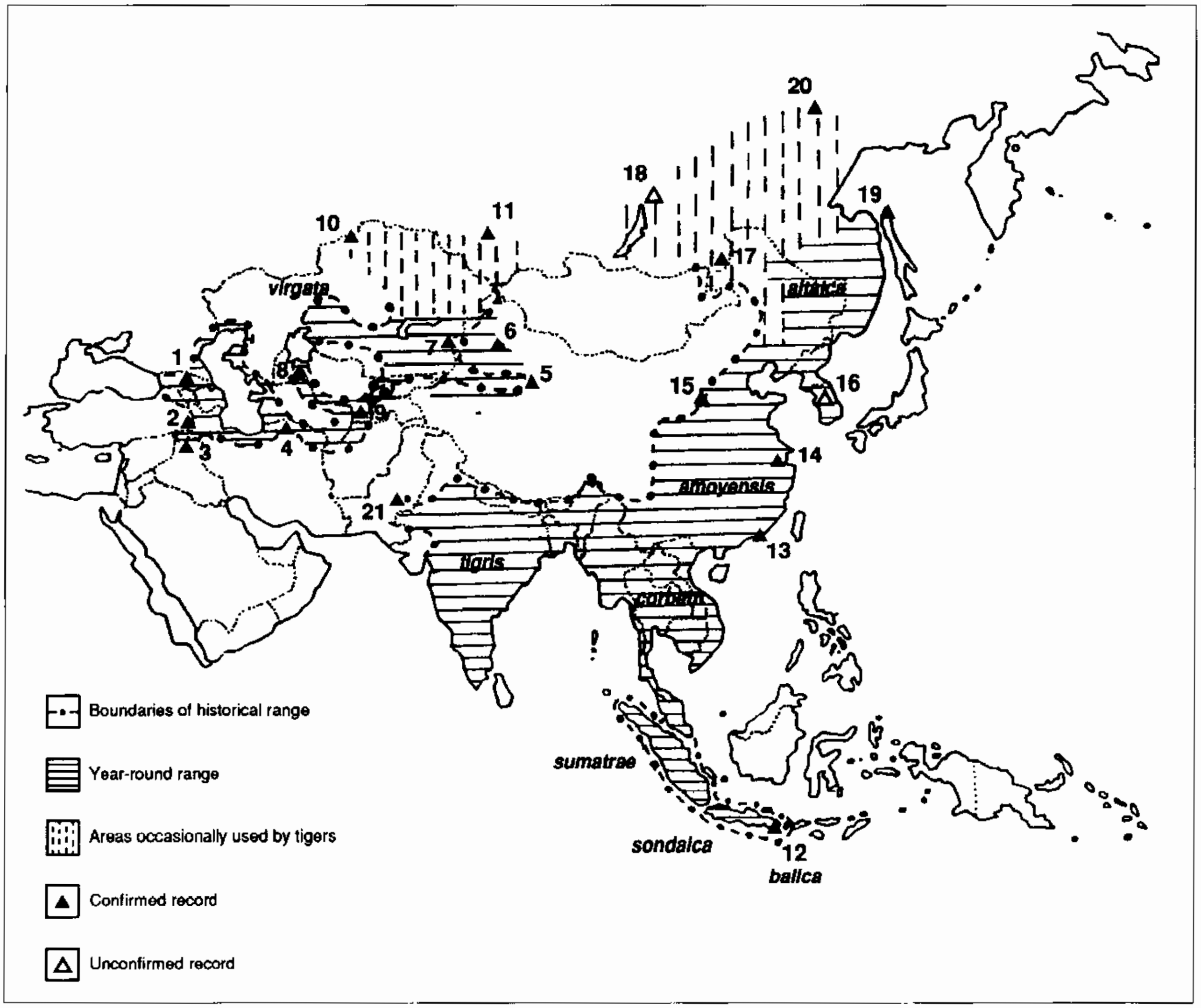

Figure 1. Historical distribution of the tiger (*P. tigris*): mid-1800s - mid-1900s (after Heptner and Sludskii 1972, Mazák 1979, 1981; Matjuschkin *et al.* 1980, Ma 1986, Wang and Wang 1986, Lu 1987).

Caspian tiger (extinct): 1. Last known tiger in the Caucasus region killed in 1922 near Tbilisi, Georgia, after taking domestic livestock (Ognev 1935). 2. Last known tiger in Turkey killed near Uludere, Hakkari province, in 1970 (Üstay 1990). 3. Only tiger reported from Iraq killed near Mosul in 1887 (Kock 1990). 4. Last known tiger in Iran killed in 1959 in Mohammad Reza Shah (now Golestan) II (Vuosalo 1976). 5. Tiger killed in 1899 near the Lob Nor basin, Xinjiang, China (Ognev 1935). Tigers disappeared from the Tarim River basin in Xinjiang by the 1920s. 6. Tigers disappeared from the Manas River basin in the Tian Shan mountains, west of Urumqi, in the 1960s. 7. Last record of the tiger on the Ili River, their last stronghold in the region of Lake Balkhash, dates to 1948. The last record from the lower reaches of the Amu-Darya river near the Aral Sea was an unconfirmed observation near Nukus in 1968 (8), while tigers disappeared from the river's lower reaches and the Pyzandh Valley (9), once a stronghold, in the Turkmen-Uzbek-Afghan border region by the early 1970s (Heptner and Sludskii 1972). In the mid-1800s, tigers were killed 180 km northeast of Atbasar, Kazakhstan (10) and near Barnaul, Russia (11) (Ognev 1935, Mazák 1981: see below for a note on these records). **Java and Bali tigers (extinct):** 12. Most of the eight Bali tiger specimens entered the world's museums in the 1930s; tigers probably disappeared from the island by the end of World War II. Tigers were eliminated from most of Java by the 1940s, and were restricted to Meru Betiri II by 1970. Tigers were last observed in Meru Betiri in 1976 (Seidensticker 1986). **South China tiger:** 13. Tiger killed in Hong Kong in 1942 (Jackson 1991a); 14. Two young tigers killed near Hangzhou, Zhejiang province, China in 1933 (Allen 1938). **Amur tiger:** 15. Tiger captured near Jiexiu, Shanxi province, China (Allen 1938); 16. The tiger probably disappeared from South Korea during the time of the Korean War (Won 1981); 17. Tiger killed near Nerchinskiy Zavod, Russia, in 1884 (Ognev 1935); 18. Tiger observed near Lake Baikal in 1875 (Guggisberg 1975, Mazák 1981); 19. In the late 1800s, tigers sometimes crossed the frozen Tatar Strait to Sakhalin Island in the winter (Guggisberg 1975); 20. Northernmost record (about 60° 40' N lat.): tiger killed in 1905 on the Aldan River, 80 km north of Ust' Maya, Russia; fresh tiger tracks were seen in the same area 5 days later (Ognev 1935, Mazák 1981). These outlying records in the north of the tiger's range in the former Soviet Union are located up to 1,000 km (20) outside the tiger's permanently inhabited range, when tigers followed herds of migratory prey species (reindeer, wild pig). The Kazakhs recognized this phenomenon in their region by naming the tiger the "road" or "travelling leopard" (Heptner and Sludskii 1972). **Bengal tiger:** 21. Last known tiger in Pakistan shot in 1906 near Panjnad, Bahawalpur state (Roberts 1977).

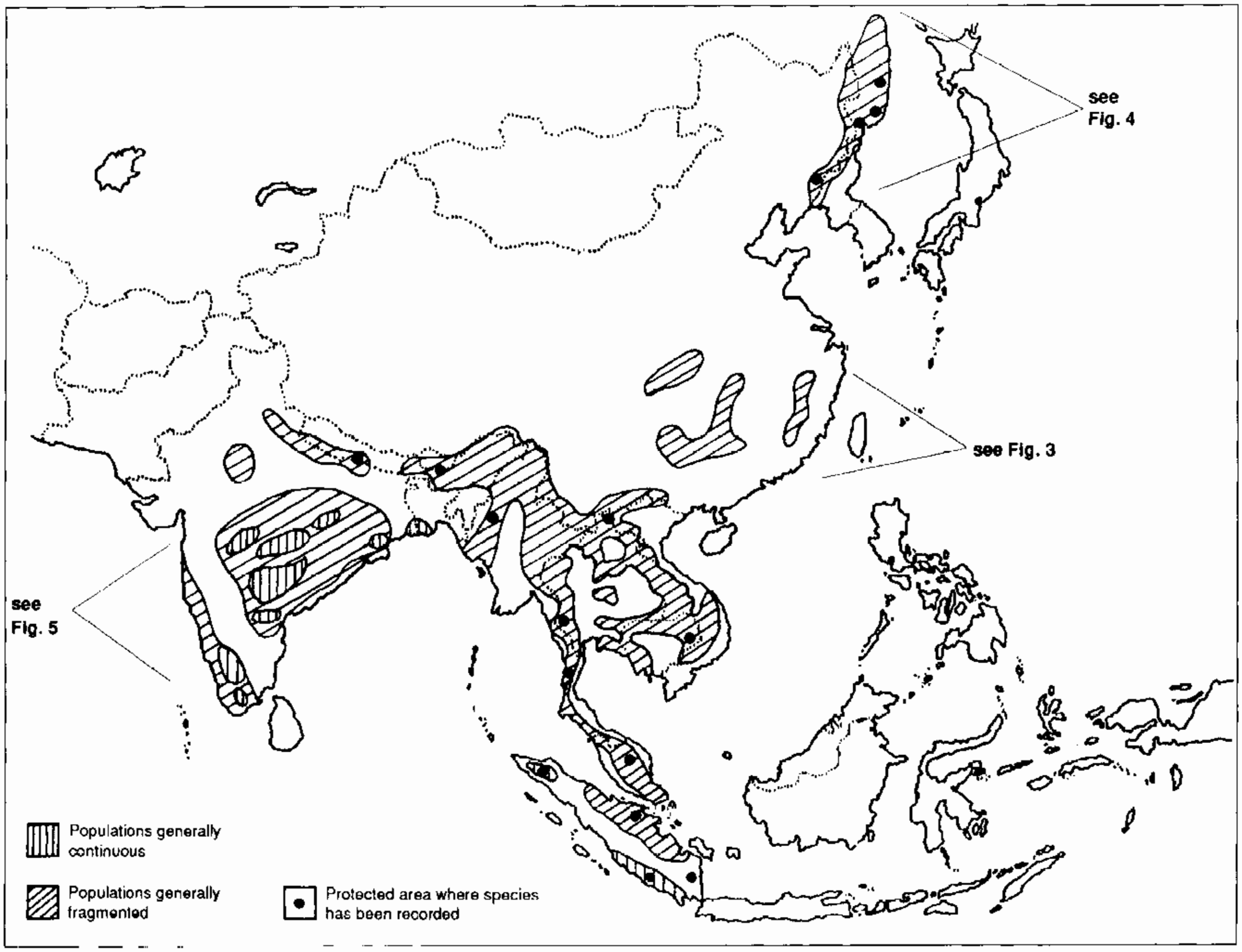

Figure 2. Present distribution of the tiger. See text under Occurrence in Protected Areas.

The Amoy, or South China tiger, (*P.t. amoyensis*), estimated by Lu and Sheng (1986) to number 4,000 in the early 1950s, was virtually extirpated when officially hunted as a pest. They state that about 3,000 tigers were killed in 30 years. Official government statistics showed that annual average numbers of skins taken dropped from 78.6 in the early 1950s, to 30.4 in the early 1960s, to 3.8 in the early 1970s, and to one by 1979, when the government finally banned hunting (Lu and Sheng 1986). Recent surveys found evidence of tiger presence and reproduction in southern and northern Hunan, northern Guangdong, and western Fujian. Tiger presence was also noted in eastern Hunan, and was reported recently from central Jiangxi (Koehler 1991, Gui and Meng 1993). The main areas of tiger distribution are montane sub-tropical evergreen forest along provincial borders (Fig. 3). The habitat is highly fragmented, with most blocks less than 500 km^2. The total population size is probably only some 30-80 animals (Jackson 1993a). The captive population is also too small, numbering only around 50 relatively inbred animals, all housed within Chinese zoos (Tilson *et al.* 1992).

The Amur tiger (*P.t. altaica*) is virtually confined to the Russian Far East, although a few may survive along China's northeast border area, and possibly also in North Korea (Jackson 1993a; Figs. 2 and 4). The Russian tigers (most located in Primorye territory, with a smaller population in Khabarovsk) have come under increased poaching pressure in recent years as political and economic change has swept over the region (Anon. 1993a,g-h; Pikunov 1994). Tigers in Russia in 1994 numbered only 150-200 (A. Amirkhanov, Deputy Minister for the Environment, in Anon. 1994c). A comprehensive census in the mid-1980s estimated a minimum of 250 and a maximum of 430 tigers (Pikunov 1988, Bragin and Gaponov 1990). The Russian tiger population had fallen as low as 20-30 animals in the 1930s, but recovered under protection from hunting extended in 1947 (Matjuschkin *et al.* 1980). There was intense debate in the late 1980s over Russian proposals to reduce the number of tigers through sport hunting, with proponents pointing to the increase in tiger attacks on livestock and arguing that there were more tigers than the prey base could support (Jackson 1987, Pikunov 1988, Bragin and Gaponov 1989, Shchadinov 1989). The wave of poaching has ended discussion of this issue, and the Russian government and NGOs are cooperating to improve anti-poaching protection (Anon. 1993h, Pikunov 1994).

The Sumatran tiger (*P.t. sumatrae*) has also suffered from poaching, as well as loss of habitat to human settlement. A Population and Habitat Viability Analysis (PHVA) workshop held in Sumatra estimated the island's tiger population at about 400 with relatively good prospects in five major reserves, and up to 200 scattered in other areas of the island (Tilson 1992a).

Tigers require adequate prey, cover, and water. Their ranges vary in accordance with prey densities. While females need ranges suitable for raising cubs, males seek access to females and have larger ranges. Thus, in areas rich in prey throughout the year, such as Nepal's Chitwan NP and India's Kanha NP, female ranges of 10-39 km^2 and male ranges of 30-105 km^2 have been recorded (Sunquist 1981), while in the Russian Far East, where prey is unevenly distributed and moves seasonally, ranges are as large as 100-400 km^2 for females and 800-1,000 km^2 for males (Matjuschkin *et al.* 1980). Bragin (1986) estimated adult tiger density at 1.3-8.6 (including young) per 1,000 km^2 in the Sikhote-Alin mountains of eastern Russia, while Karanth's (1991) review shows that high quality tropical habitats can support 7-12 tigers (including young) per 100 km^2.

The table above shows the range of various density estimates, and indicates the considerable ecological flexibility of the tiger.

Protection Status

CITES Appendix I. The Amur tiger subspecies was upgraded from Appendix II to Appendix I in 1987. National legislation: protected over most of its range. Hunting prohibited: Bangladesh, Bhutan, Cambodia, China, India, Indonesia, Laos, Malaysia, Myanmar, Nepal, Russia, Thailand, and Vietnam. No information: North Korea (Fuller *et al.* 1991, Jackson 1993a).

Occurrence in Protected Areas

The tiger, like other big cats, probably has little future outside protected areas because of actual and perceived threats to livestock and human life. Its current range extends through one of the most densely inhabited regions of the world, where human populations are rising at an average of 1.87 percent per annum (WRI/UNEP/UNDP 1992). In India, the human population had increased by over 300 million (nearly 50%) and livestock by over 100 million during the 20 years since Project Tiger began (Govt. of India 1993).

Bangladesh: Tigers are found throughout the Sundarbans mangrove forests, including the small reserves (total area 320 km^2) of Sundarbans East, South & West IV, and may

Table 2
Densities Reported for Tigers in Different Habitats
(Adapted from Karanth 1991 and Rabinowitz 1993)

Location	Habitat Type	Ungulate Prey[1]	Tiger Density[2]
Nagarhole II, India	Broad-leaved humid forest	Very high	11.65
Ranthambore II, India	Tropical dry forest	Medium-high	10.00
Chitwan II**, Nepal	Moist monsoon and riparian forest	High	8.78
Kanha II, India	Moist monsoon forest/meadows	High	6.92
Bengkulu, Sumatra	Lowland rain forest	Medium-high	3.7[3]
Gunung Leuser II*, Sumatra	Montane and lowland humid forest	Medium-low	1.1-2.2[3]
Huai Kha Khaeng IV, Thailand	Mixed seasonal forest	Low	1.0[3]
Lazovskiy I, Russia[4]	Mixed deciduous-coniferous woods	Low	0.6-0.86
Sikhote Alin I*, Russia[4]	Mixed deciduous-coniferous woods	Very low	0.13-.45

1 Indexed according to Rabinowitz (1993), with prey biomass in Nagarhole (7,658 kg/km^2: Karanth 1991) at the high end of the scale.
2,3 Tiger densities expressed in number of tigers per 100 km^2, including young and transients. Those estimates marked 3 include adults only.
4 Data from Matjuschkin *et al.* (1980) and Bragin (1986).

number about 300 (Anisuzzaman Khan *in litt.*) or 460 (Farooq Sobhan, Bangladesh Ambassador at Global Tiger Forum, New Delhi, 1994). They may still occur in Teknaf VIII, located in the extreme southeastern tip of the country bordering Myanmar (MacKinnon and MacKinnon 1986).

Bhutan: Bhutan's nine lowland protected areas along the southern border with India are all believed to contain tigers (Jackson 1993a, Anon. 1994c). Royal Manas II, which adjoins India's Manas II**, is the largest and most significant (shown in Fig. 2). Tigers occur at lower elevations in Jigme Dorji IV, an enormous reserve comprising the entire northern third of the country (Dorji and Santiapillai 1989). The Bhutanese government announced a census result of 237 at the 1994 Global Tiger Forum, noting that some tigers are shared with India (Dasho Penjore Dorji, pers. comm.). Non-official estimates in 1993 (Jackson 1993a) put the population at 20-50.

Cambodia: Tigers have been recorded in the proposed Lomphat reserve (shown in Fig. 2; MacKinnon and MacKinnon 1986: 237-244), but there have otherwise been no surveys to map tiger distribution in Cambodia (Chim Somean, Wildlife Protection Office, in Anon. 1994c).

China: In China, a 1990 survey found South China tiger signs in 11 reserves (Koehler 1991); a total of 19 fall within its present range (Gui and Meng 1993). Total protected area coverage is about 2,500 km^2. Gui and Meng (1993) identify 12 additional sites, with a total area of 6,000 km^2, which they recommend for protection (Fig. 3). Sightings of Amur tigers in Changbai Mts. IV* (1,905 km^2) in northeastern China were reported in Chinese newspapers in 1990 (Anon. 1991f; shown in Fig. 2).

India: India has 21 reserves specifically managed for tigers which cover over 30,000 km^2 and contain about 1,300 tigers, about one-third of the country total of 3,750 (Ghosh 1994). Over half this area consists of buffer zones, with human settlement, agriculture, and livestock grazing. Tigers are also found in about 80 other protected areas, in most of which people and livestock are present. The

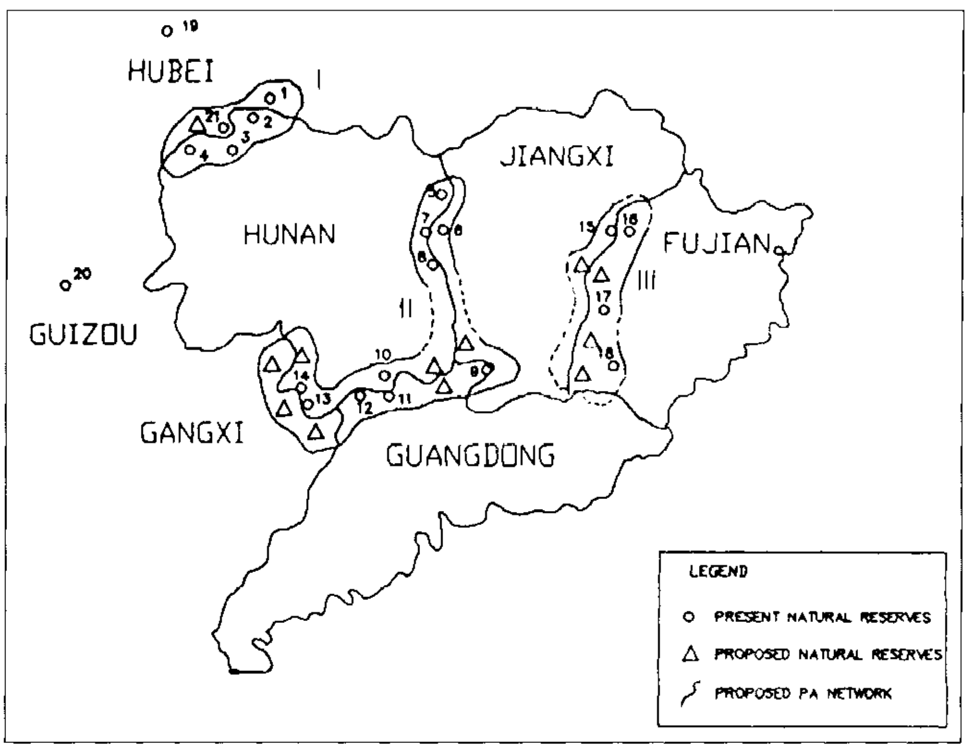

Figure 3. Current distribution of the South China tiger, with protected areas and proposed network (Gui and Meng 1993). 1. Houhe Nature Reserve (20 km^2); 2. Mt. Huping IV (440 km^2); 3. Wulingyun Mt. Nature Reserve (108 km^2); 4. Badaguang Mt. IV (180 km^2); 5. Dawei Mt. IV (50 km^2); 6. Jinggang Mts. IV (53 km^2); 7. Taoyundong IV (60 km^2); 8. Bamian Mt. IV (42 km^2); 9. Chebaling IV (75 km^2); 10. Mang Mt. IV (64 km^2); 11. Babao Mt. IV (32 km^2); 12. Chenzia IV (78 km^2); 13. Dayunyunko IV (103 km^2); 14. Qianjiadong IV (52 km^2); 15. Wuyi Mt IV (53 km^2); 16. Wuyi Mts. IV (565 km^2); 17. Meihua Mt. IV (221 km^2); 18. Mangdan Mt. Nature Reserve (42 km^2); 19. Shennongjia (Shewengia) IV (705 km^2); 20. Mt. Fanjing IV (419 km^2); 21. Xiaolingzh IV (21 km^2).

Wildlife Institute of India has identified 12 large blocks of remaining forest with the potential to conserve tiger populations with long-term viability (Johnsingh *et al.* 1991: Fig. 5). They contain both state forests, managed for timber production, and 47 wildlife reserves, including those specifically managed for tiger. However, one major reserve, the Melghat Tiger Reserve, one of the first such reserves specially declared under Project Tiger, is slated to be reduced by 1/3 to just 1,046 km^2 in order to accommodate the large number of people living within the reserve (Aziz 1994). Tigers may disappear in a few decades from 56 other reserves because of low numbers and human pressures (Johnsingh *et al.* 1991). This could mean the loss of perhaps up to half the 3,000-4,000 tigers currently thought to survive in India.

Indonesia (Sumatra): The major reserves for tigers on Sumatra are Gunung Leuser II* (9,000 km^2) in the northwest of the island (Fig. 2), Kerinci Seblat/Barisan Selatan II complex (along the southeast coast (Fig. 2), Way Kambas II (shown in Fig. 2), and Berbak IV on the northern coast. Tilson (1992a) notes that habitat within Kerinci Seblat is significantly fragmented, and tiger populations are probably also fragmented.

Korea, North: Tigers may possibly survive in North Korea, and Mt. Paekdu IV*, a border area reserve which adjoins China's Changbai Mts. IV*, is a likely place.

Laos: Salter (1993) surveyed villages within and near 18 areas which have been proposed as the basis of a national protected area system. Tigers were reported present near the majority of villages in all areas.

Malaysia: Tigers have been reported from most protected areas in peninsular Malaysia (Khan 1987). The largest, Taman Negara II (4,344 km^2), is shown in Fig. 2.

Myanmar: Myanmar's protected areas have not been surveyed for tiger presence since Salter (1983) reported them as most abundant in Alaungdaw Kathapa II (shown in Fig. 2). Salter (1983) and WCMC (unpubl. data) also mention tiger presence in other areas, including Shwe-U-Daung, Shwesettaw and Tamanthi Wildlife Sanctuaries; Pidaung Game Sanctuary; Kyaukpandaung, Natma Taung and Pegu Yomas proposed National Parks; Pakchan proposed Nature Reserve on the Tenerassim peninsula (shown in Fig. 2) and Dipayon and Meinmahla Kyun proposed Wildlife Sanctuaries.

Nepal: In Nepal, tigers are found almost exclusively in Royal Chitwan II** (shown in Fig. 2), Royal Bardia II, and Royal Sukhla Phanta and Parsa IV.

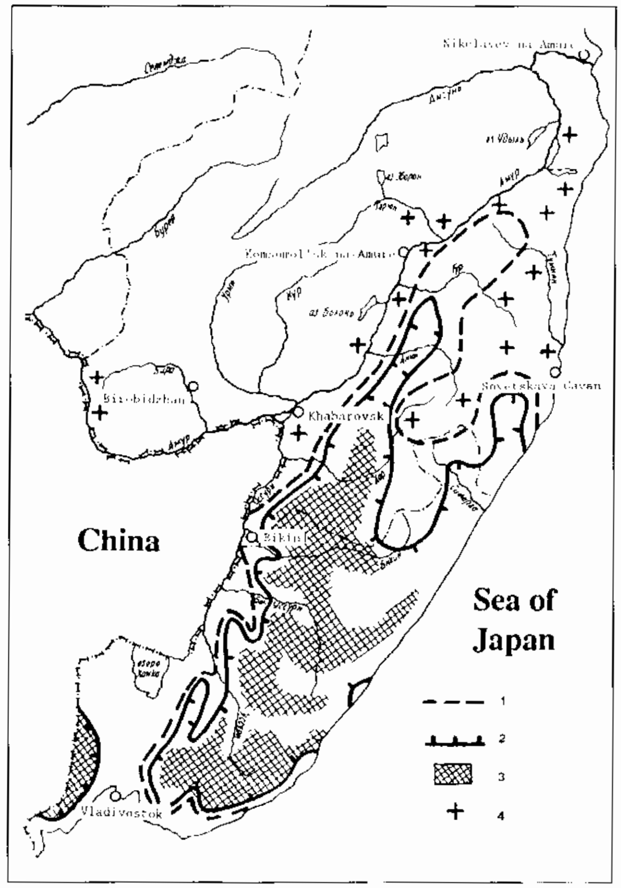

Figure 4. Distribution of the Amur tiger in the Russian Far East (D. Pikunov *in litt.*). 1. limits of regular records; 2. limits of natural habitat; 3. zones of high density; 4. scattered records.

Russia: Tigers occur, from north to south in Fig. 2, in the Sikhote Alin* (3,471 km^2), Lazovskiy (1,165 km^2) and Kedrovaya Pad (179 km^2) I. Unlike most other parts of its range, the Amur tiger in Russia lives mainly outside protected areas (Bragin and Gaponov 1989). A survey of Lazovskiy Reserve in early 1993 estimated the population at 22 tigers (14 adults and eight sub-adults), with perhaps 10 (eight adults and two sub-adults) living on the periphery (G. Salkina, pers. comm. 1993; Anon. 1993g). Bragin (1986) estimated the population of the larger Sikhote Alin Reserve, of which up to 1/3 is not suitable in terms of vegetation or prey base for tigers, at 25 adults. Few confine their movements solely to the reserve (Bragin and Gaponov 1989). Korkishko and Pikunov (1994) estimated that there were nine tigers (four males [three adult, one sub-adult]; five females [four adult, one sub-adult]) in the Kedrovaya Pad in 1991; it is unlikely that they were all permanent residents. Thus, only about 20% of Russia's tiger population is found in protected areas. Outside these areas, commercial logging and hunting of ungulates are on the increase.

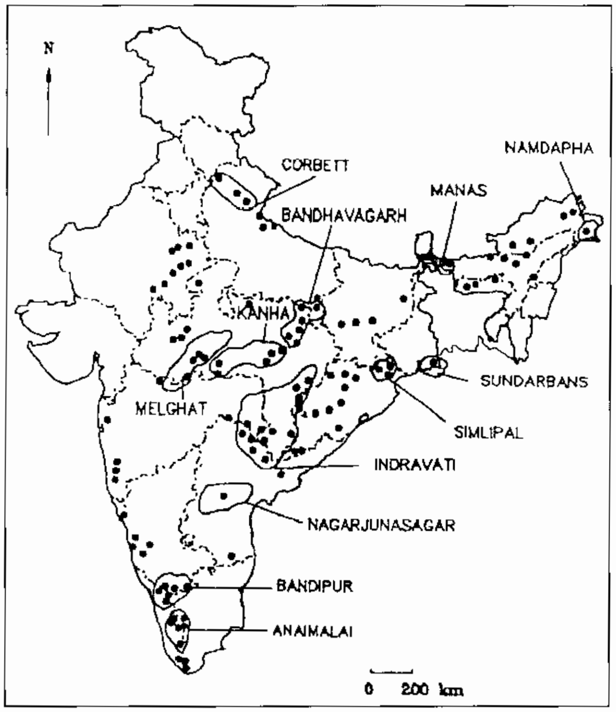

Figure 5. Proposed blocks of protected areas for tigers in India (Johnsingh *et al.* 1991). Twelve habitat blocks (including 47 protected areas as well as state forest land) are identified which have the potential to conserve large viable tiger populations. The name of one key protected area is given for each unit.

Thailand: In Thailand, Rabinowitz (1993) confirmed the presence of tigers in 22 protected areas, out of 38 visited. Sixteen reserves were less than 500 km^2 in area. He listed eight forest complexes or sites >2,000 km^2 containing Thailand's largest tiger populations: Huai Kha Khaeng-Thung Yai IV complex (>12,000 km^2: shown in Fig. 2); Nam Nao II complex (>4,000 km^2); Kaeng Krachan IV complex (>3,000 km^2); Thap Lan II complex (>3,000 km^2); Huai Nam Dang (proposed II) complex (>3,000 km^2); Khlong Saeng IV complex (>2,000 km^2); Mae Tuen IV complex (>2,000 km^2) and Khao Yai II (>2,000 km^2).

Vietnam: Evidence for tiger presence has been found recently in 14 reserves: Bach Ma Hai Vin and Nam Bai Cat Tien II; Anh Son, Bu Gia Map, Kon Cha Rang, Mom Ray, Muong Nhe (Cha), Xuan Nha and Yok Don IV; and Muong Phang, Muong Te, Pong Quang, Pia Oac and Pu Nhi Reserves (Nguyen Xuan Dang and Pham Trong Anh 1992). Muong Nhe, the largest reserve (1,820 km^2), is shown on Fig. 2. The others are less than 600 km^2 in area.

Principal Threats

Commercial poaching, a declining prey base due to overhunting, and loss of habitat are the principal threats to the tiger. Maintenance of present habitat is crucial to the tiger's future, along with protection from illegal killing. Seidensticker (1986) attributed the extirpation of tigers on Bali and Java to extensive habitat fragmentation and the insularization of small habitat blocks and reserves (<500 km^2), widespread loss of critical ungulate prey through disease, and overhunting by humans.

Tigers are shot or poisoned for livestock predation and for financial gain. Large numbers of tigers were killed in the 20th century in Russia and China where they were officially considered pests, and bounties were paid for their destruction. In terms of commerce, tigers have traditionally been hunted primarily for their skins: Heptner and Sludskii (1972) point to the rising price of tiger skins as being an important factor leading to their decline in central Asia and the Russian Far East in the late 1800s to early 1900s. In addition, tiger bone and other body parts are used in traditional Chinese and Korean medicines. In the early 1900s, Russians sold frozen tiger carcasses whole to Chinese marketeers and pharmacists (Heptner and Sludskii 1972). Today, the changed political and economic conditions in the former Soviet Union, and what appears to be a combination of increased demand among Asian consumers coupled with a decreased supply of wild tigers, have made poaching for bone the pre-eminent threat to the Amur tiger. Heavy poaching, again primarily for bone, is also taking place in India, and probably elsewhere throughout the tiger's range. The tiger bone trade is discussed in detail in Part II, Chapter 4; livestock depredation is covered in Part II, Chapter 2.

Hunting of tigers for sport has also played a role in their historical decline. Tiger hunting was prevalent throughout the range from early times. It became very fashionable when firearms were introduced to the Indian sub-continent, where it was pursued enthusiastically by British officials and Indian upper classes. For example, when King George V hunted with the Maharajah of Nepal in 1911, the party shot 39 tigers in 11 days. The bag record is claimed by the Maharajah of Surguja, who in 1964 wrote to George Schaller that he had shot 1,150 tigers "only" over his lifetime (Schaller 1967). Russian soldiers moving east in the 19th century hunted tigers as part of their military training to increase their courage in battle (Heptner and Sludskii 1972). While historical records from India suggest that tiger populations withstood heavy offtakes for long periods of time (M.K. Ranjitsinh, pers. comm.), tiger populations became more vulnerable as habitat decreased, particularly after World War II. Sport hunters from Europe and the Americas flew into India and Nepal to obtain trophies with little official control. Official records in India show that 480 tigers were shot by sport hunters in the years 1966-1969. It is likely that many more were shot or poisoned. Hundreds of skins were exported annually before a ban in 1968 (Anon. 1994f).

On the other hand, subsistence hunting of ungulate prey by local people is now a powerful force driving the tiger's decline over large parts of its range. Rabinowitz (1989) noted an unexpected low abundance of tigers combined with a reduced number of banteng, gaur, and sambar in Huai Kha Khaeng Wildife Sanctuary in Thailand. U. Karanth (pers. comm.) suggests that, in tropical Asia, it is unlikely that tigers can reproduce successfully at prey densities below 2-5 ungulates per km^2 .

Further north, tigers expand their home ranges to account for the seasonal movements of a lower density ungulate prey base. The highest density tiger population in Russia, in the Lazovskiy Reserve, occurred amidst a relatively high prey density of 2.25 ungulates per km^2 (Bragin 1986). However, Amur tigers are naturally vulnerable to sharp declines in ungulate populations during severe winters, and starvation at this time is a common phenomenon. Hepter and Sludskii (1972) relate reports of emaciated adult tigers in winter weighing as little as 70 kg: the stomach of one contained nothing but lichens. They report that, in the Primorye region, winters with abundant snow occur on average once every four years. Such harsh seasonal conditions increase the precarious situation of the Amur tiger. Since the collapse of the U.S.S.R., poaching of both tigers and their prey has led to a rapid decline in the population from 250-430 in the mid-1980s (Pikunov 1988, Bragin and Gaponov 1990) to 150-200 (A. Amirkhanov, Deputy Minister, in Anon. 1994c)

Severe habitat loss has occurred in this century with the growth and spread of human populations, settlement, and activities. Not only have large blocks of tiger habitat been converted to human use, but wilderness has been fragmented, creating many isolated tiger populations, some so small that genetic deterioration is to be feared (Smith and McDougal 1991). As Seidensticker (1987) declared in his review of the extinctions of the Bali and Javan tigers, it is dangerous to rely on small, isolated reserves. Large tracts of contiguous habitat are essential to assure the long-term survival of wild tigers. The problems of conserving tigers are discussed in Part II, Chapters 1 and 3.

Action Planning

Projects 12 and 44-56.

Bornean bay cat, *Catopuma badia* (Gray, 1874)

Other Names

Chat bai (French); Borneo-katze (German); gato rojo de Borneo (Spanish); kucing merah (Indonesia, Malaysia); kucing Kalimantan (Indonesia).

Description and Behavior (Plate 9)

The Bornean bay cat is the mystery cat of the family. Its description rests on just a few skins and skulls, most collected in the late 1880s, scattered in several museums around the world (Sunquist *et al.* 1994a). Tissue and blood samples for genetic analysis were acquired only in late 1992, when a female captured by trappers on the Sarawak-Indonesian border was brought to the Sarawak museum on the point of death. The cat weighed 1.95 kg, but was estimated to have weighed between 3-4 kg when healthy (Sunquist *et al.* 1994b). No observations of the bay cat's behavior or ecology have been made since Hose (1893).

The Bornean bay cat has two color phases: chestnut-red, the more common, and grey (Pocock 1932, Sunquist *et al.* 1994b). The coat of the 1992 female was speckled with black markings (Sunquist *et al.* 1994a). Her tail was long: at 391 mm, 73% of head-body length (533 mm). On all specimens, the backs of the rounded ears are darker-colored, and a whitish stripe runs down the ventral surface of the terminal half of the tail. The bay cat resembles the Asiatic golden cat not only in these characters, but also in skull dimensions, and may well be an island form (Weigel 1961, Hemmer 1978a, Groves 1982). The Asiatic golden cat occurs widely throughout southeast Asia, including Sumatra but not Borneo. Borneo has been separated from Sumatra and other islands on the Sunda Shelf for 10,000-15,000 years (Sunquist *et al.* 1994a). Genetic analysis indicates a close relationship to the Asiatic golden cat (Collier and O'Brien 1985).

Biology

No information.

Habitat and Distribution

Found only on the island of Borneo. Collection and sighting records with fairly precise locations, shown in Fig. 6, are all from the highlands, and most are near rivers, although the latter may reflect a collecting bias (Payne *et al.* 1985; C. Groves, P. Pfeffer, J. Payne *in litt.* 1993; Sunquist *et al.* 1994b). The record from Mt. Kinabalu is an unconfirmed sighting at 1,800 m (Payne *et al.* 1985). In northeastern Kalimantan in the late 1950s, P. Pfeffer (*in litt.* 1992) twice saw the fur of the bay cat in Dyak ceremonial caps. S. Yasuma (*in litt.* 1987, 1988, 1993) has looked in vain for evidence of the bay cat in the Bukit Suharto Protection Forest, located 60 km south of Samarinda in the eastern coastal lowlands of Kalimantan. According to Hose (1893), dense primary forest is preferred, but recently several biologists have sighted a bay cat at night in logged dipterocarp forest along the access road to the Danum Valley Field Studies Centre in eastern Sabah (J. Gasis, P. Hurrell, S. Yorath, pers. comm. to J. Payne 1993).

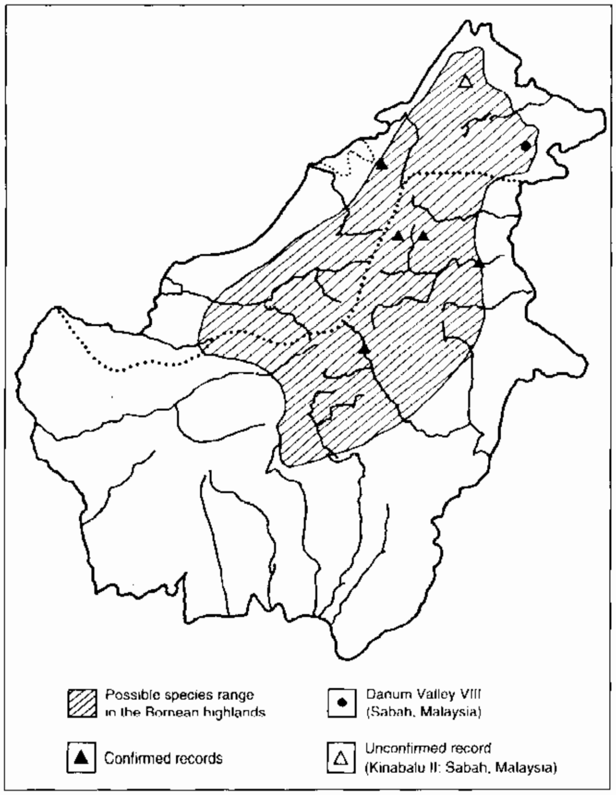

Figure 6. Possible distribution of the Bornean bay cat (*C. badia*).

Population Status

Global: Category 2. Regional: Category 1. IUCN: Insufficiently Known. The bay cat has long been considered rare (Hose 1893). A faunal survey of Sabah (Davies and Payne 1982) found no evidence of the bay cat. Rabinowitz *et al.* (1987) interviewed villagers in Sabah and Sarawak about local occurrence of clouded leopards, using pictures in a field guide (Payne *et al.* 1985). While many informants had seen clouded leopards, leopard cats, flat-headed cats, and marbled cats, none pointed to the picture of the Bornean bay cat (J. Payne *in litt.* 1993). The trappers who captured the bay cat in 1992 were apparently aware of its rarity and value to an animal dealer (Sunquist *et al.* 1994b).

Protection Status

CITES Appendix II. National legislation: fully protected over most of its range. Hunting and trade prohibited: Indonesia, Malaysia (Sabah and Sarawak). No legal protection outside reserves: Brunei (Nichols *et al.* 1991).

Principal Threats

Unknown, probably deforestation (Collins *et al.* 1991). On a positive note, P. Pfeffer (*in litt.* 1992) notes that the same area of eastern Kalimantan where the fur caps were seen in 1955-1957 was visited again in 1986 and 1989. The forest was still undisturbed and less populated, as most villagers had migrated toward the coastal lowlands.

Action Planning

Project 57.

Clouded leopard, *Neofelis nebulosa* (Griffith, 1821)

Other Names

Panthère longibande, panthère nébuleuse (French); Nebelparder (German); pantera longibanda, pantera nebulosa (Spanish); lamchita, gecho bagh (Bengali: Bangladesh, India); yunbao (Chinese); engkuli (Iban: Malaysia); machan dahan (Indonesia, Malaysia); shagraw kai (Kachin: Myanmar); lamchitia (Khas: Nepal); sua one (Laos); thit kyaung, thit-tet kya [tree-top leopard], in kya (Myanmar); rikulau (Rukai, Paiwan: Taiwan); hso awn (Shan); seua laay mek (Thailand).

Description and Behavior (Plate 8)

The clouded leopard is named after its distinctive markings—ellipses partially edged in black, with the insides a darker color than the background color of the pelt, and sometimes dotted with small black spots. Pelt color varies from ochraceous to tawny to silvery grey (Pocock 1939a). Black and pale, whitish individuals have been reported from Borneo (Medway 1965, Payne *et al.* 1985, Rabinowitz *et al.* 1987, S. Yasuma *in litt.* 1993). The limbs and underbelly are marked with large black ovals, and the back of its neck is conspicuously marked with two thick black bars. The tail is thick and plush, encircled with black rings, and very long, typically equivalent to head-body length (up to 80-90 cm: Pocock 1939a, Legakul and McNeely 1977, Mehta and Dhewaju 1990). Swinhoe (1862) described the Formosan clouded leopard as a distinct subspecies (*F.n. brachyurus*) on the basis of a shorter tail length (55-60 cm), but Pocock (1939a) found that tail length is not a consistent criterion. The legs of the clouded leopard are short, but its canines are relatively the longest of any felid (3.8-4.5 cm: Guggisberg 1975), and have a very sharp posterior edge. Werdelin (1983a) analyzed morphological characters in the skulls of cats, and concluded that the clouded leopard has attained pantherine cranial proportions (especially large teeth) without reaching pantherine cranial size. Clouded leopards are intermediate in size between large and small cats: wild adults have weighed between 11-20 kg (Pocock 1939a, Banks 1949, Prater 1971).

The clouded leopard has arboreal talents rivalling those of the margay of South America. In captivity, it has been seen to run down tree trunks headfirst, climb about on horizontal branches with its back to the ground, and hang upside down from branches by its hind feet (Hemmer 1968). It probably does some foraging in trees, but mainly uses them for resting (Rabinowitz *et al.* 1987, Davies 1990, W. Brockelman *in litt.* 1993). Most photos taken by camera traps in Sumatra's Gunung Leuser National Park, where tigers occur, were at night (Griffiths 1993). There is speculation that the clouded leopard may be less nocturnal in Borneo, where other large carnivores are absent (Selous and Banks 1935, Davis 1962, Rabinowitz *et al.* 1987). Clouded leopards swim well, and have been found on small islands off Sabah (Davies and Payne 1982) and Vietnam (Le 1973, C. Santiapillai *in litt.* 1991).

Pocock (1939a) surmises from the clouded leopard's long canines and stocky build that it is adapted to take relatively large ungulate prey. Prey has been reported to consist of birds, primates, and small mammals, as well as larger prey, such as porcupines, deer, and wild boar (Banks 1949, Le 1973, Prater 1971, Rabinowitz *et al.* 1987, S. Yasuma *in litt.* 1993), but the few data collected by scientists have been mainly of primates. In Sabah, a clouded leopard was observed feeding on a proboscis monkey in the branches of a small tree in riverine forest (J. Payne *in litt.* 1992), and one shot in coastal mangrove in northern Borneo in 1950 had also just killed a large male proboscis monkey (Davis 1962). Griffiths (1993) found mainly remains of primates, but also muntjac and argus pheasant, in a small sample of scats attributed to clouded leopards from Gunung Leuser NP. Clouded leopards have been observed hunting primates (pig-tailed macaques and gibbons) in Thailand's Khao Yai National Park (Davies 1990, W. Brockelman *in litt.* 1993).

Biology

Estrus: (C) average 6 days.

Estrus cycle: (C) average 30 days (n=72).

Gestation: (C) 93 ± 6 days (Yamada and Durrant 1989).

Litter size: (C) 1-5, most often 3 (n=7 of 9 litters: P. Andrews *in litt.* 1993).

Age at first reproduction: (C) both males and females average 26 months.

Age at last reproduction: (C) 12 (Yamada and Durrant 1989) - 15 years (P. Andrews *in litt.* 1993); most litters born to males and females between 2-4 years (Yamada and Durrant 1989).

Longevity: (C) average 11, up to 17 years (Prator *et al.* 1988).

Habitat and Distribution

The clouded leopard is usually characterized as being most closely associated with primary evergreen tropical rain forest (e.g., Banks 1949, Prater 1971), but it also makes use of other types of habitat. Sightings have also been made in secondary and logged forest (Davies and Payne 1982, Rabinowitz *et al.* 1987, Santiapillai and Ashby 1988, Johns 1989, M. Khan *in litt.* 1991), as well as grassland and scrub (Santiapillai and Ashby 1988, Dinerstein and Mehta 1989). In Burma and Thailand, its presence has been reported from relatively open, dry tropical forest (C. Wemmer in Dinerstein and Mehta 1989, Rabinowitz and Walker 1991). The clouded leopard has been recorded from mangrove swamps in Borneo (Davis 1962, Davies and Payne 1982). The clouded leopard has a wide distribution in China, south of the Yangtze (Tan 1984, China Cat Specialist Group meeting 1992), apparently occurring in a variety of forest types, but there is no information on habitat preference or ecology across this large portion of its geographic range (Fig. 7). It has been recorded in the Himalayan foothills up to 1,450 m (Biswas *et al.* 1985), and possibly as high as 3,000 m (Jerdon 1874).

Clouded leopards are remarkably secretive creatures for their size. Four animals turned up in different areas of Nepal in 1989 after more than a century's hiatus in official observation, having last been recorded in the country in 1863 (Dinerstein and Mehta 1989). The records extend the western limit of the range to central Nepal.

Population Status

Global: Category 3(A). Regional: Category 2(A). IUCN: Vulnerable. Its elusiveness, arboreality, and forest habitat make the clouded leopard a difficult subject for study (A. Rabinowitz, pers. comm.), and there has been no in-depth investigation beyond interviews with local residents or forestry workers. In Taiwan, there have been only a handful of sighting reports from hunters since the 1960s; none of them have been substantiated (Rabinowitz 1988, Nowell 1991, K.-Y. Lue, pers. comm.). Little forested habitat remains in Bangladesh and parts of northeastern India, and numbers are probably low outside protected areas (Khan 1986, Johnsingh *et al.* 1991, Choudhury 1993). Although it has a wide range in southern China, suitable forest habitat is generally fragmented in small patches (J. MacKinnon, pers. comm.).

The status of the clouded leopard is probably healthiest on the island of Borneo (Rabinowitz *et al.* 1987), possibly because of the absence of tigers and leopards. As part of a faunal survey of Sabah, Davies and Payne (1982) provided the first (and thus far only) rough estimate of density; they assumed that 12 one-square kilometer study areas were surveyed adequately so that presence or absence of clouded leopard would be detected and, on the basis of three records, came up with a density of one individual/4 km^2.

Protection Status

CITES Appendix I. National legislation: protected over most of its range. Hunting prohibited: Bangladesh, Brunei, China, India, Indonesia, Malaysia, Myanmar, Nepal, Taiwan, Thailand, Vietnam. Hunting regulated: Laos. No legal protection outside protected areas: Bhutan. No information: Cambodia (Nichols *et al.* 1991; U. Ohn, R. Salter, C. Santiapillai *in litt.*).

Principal Threats

Deforestation is the foremost threat, although the serious-

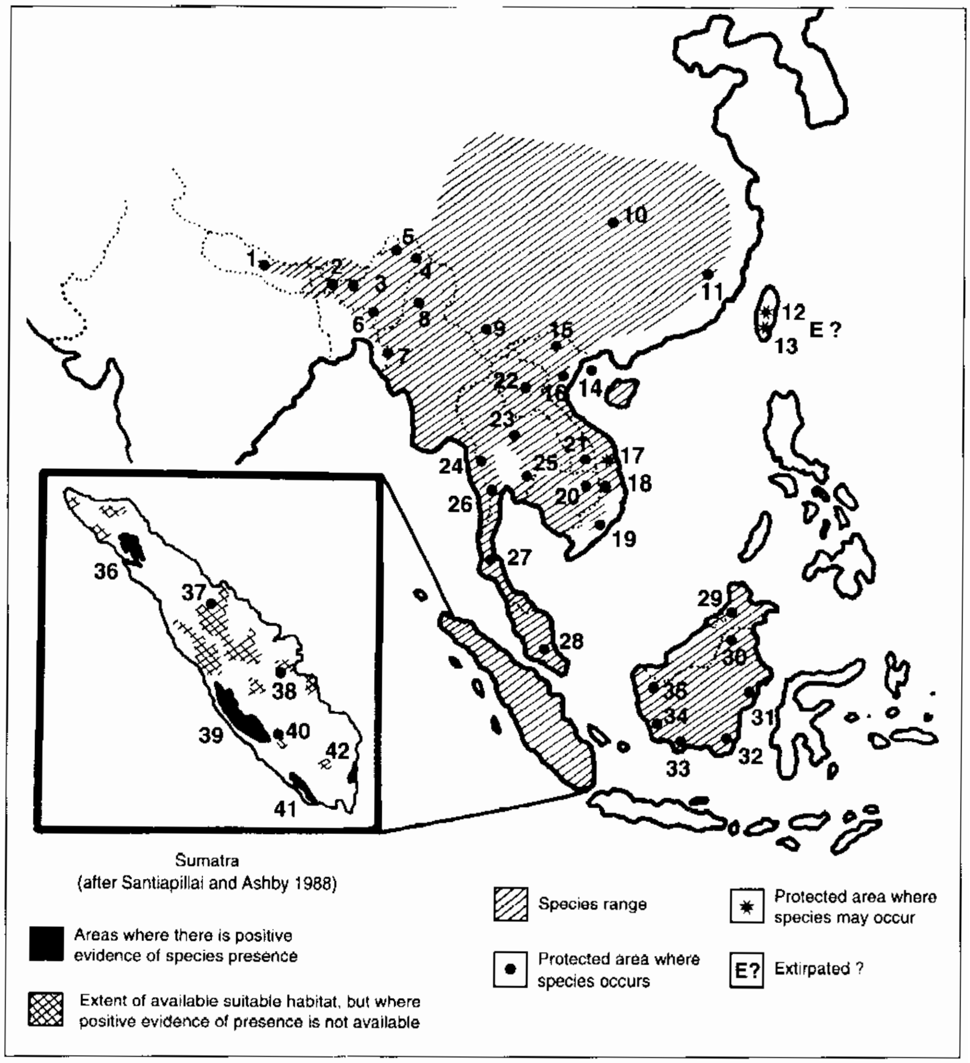

Figure 7. Distribution of the clouded leopard (*N. nebulosa*). 1. Langtang II (Nepal); 2. Buxa IV (India); 3. Manas IV** (India) + Royal Manas II (Bhutan) complex; 4. Namdapha II; 5. Mouling II (India); 6. Rajkandi Forest Reserve; 7. Pablakhali IV (Bangladesh); 8. Tamathi Wildlife Sanctuary (Myanmar); 9. Nangun River IV; 10. Mt. Fanjing IX*; 11. Wuyi Mts. IV* (China); 12. Yushan II; 13. Tawu Mts. IV (Taiwan); 14. Cat Ba II; 15. Ba Be II; 16. Cuc Phuong II; 17. Kon Kai Kinh IV complex; 18. Yok Don IV; 19. Nam Bai Cat Tien II (Vietnam); 20. Lomphat Reserve (proposed: Cambodia); 21. Xe Bang Nouane (proposed); 22. Muang Son (proposed) (Laos); 23. Nam Nao II complex + Phu Luang IV; 24. Huai Kha Khaeng IV complex; 25. Khao Yai II complex; 26. Kaeng Krachan IV; 27. Khlong Saeng IV complex (Thailand); 28. Krau IV; 29. Crocker Range II (Malaysia); 30. Sungai Kayan Sungai Menteran I; 31. Kutai II; 32. Pleihari Martapura IV; 33. Tanjung Puting II* complex; 34. Gunung Palung I; 35. Gunung Penrisen/Gunung Niut Game Reserve; 36. Gunung Leuser II*; 37. Torgamba Production Forest; 38. Tigapulu Hills; 39. Kerinci Seblat II; 40. Gumai Pasemah IV; 41. Barisan Selatan II; 42. Way Kambas IV (Indonesia).

ness depends upon further study of the species' tolerance of various degrees of forest clearance (Rabinowitz *et al.* 1987). Secondly, the clouded leopard is widely hunted for its teeth and decorative pelt, and for bones for the traditional Asian medicinal trade. Clouded leopard pelts were the most commonly available felid pelts in a survey of black market wildlife traders in southeastern China (Low 1991). Taiwanese were the main buyers. In Taiwan, where clouded leopards are now either very rare or extinct, Nowell (1990) reported that small numbers of imported pelts are sold to aborigines to make traditional ceremonial jackets. Pelts have also been reported on sale in urban markets from Myanmar, Laos, Vietnam, Cambodia, Nepal, and Thailand (Salter 1983, Chazee 1990, Humphrey and Bain 1990, MacKinnon 1990, Van Gruisen and Sinclair 1992; R. Salter, TRAFFIC Southeast Asia *in litt.* 1993). Clouded leopards have been featured on the menu of restaurants in Thailand and China which cater to wealthy Asian tourists (Anon. 1988).

Action Planning

Projects 58 and 59.

Asiatic golden cat, *Catopuma temmincki* (Vigors and Horsfield, 1827)

Other Names

Temminck's cat (English); chat doré d'Asie (French); Asiatische Goldkatze (German); gato dorado asiatico (Spanish); xonali mekoori (Assamese, India); shonali biral (Bengali: Bangladesh, India); jin mao, huang hu, zhi ma bao (Chinese); kucing emas (Indonesia); sua meo, sua pa (Laos); kucing tulap, harimau anjing (Malaysia); kya min, kyaung min (Myanmar); hso hpai, miao thon (Shan); sua fai [fire tiger] (Thailand).

Description and Behavior (Plate 9)

The Asiatic golden cat is remarkably polymorphic in its pelage. The most common coloration is fox-red to gold-brown, but it can also be black, brown, or grey. There is a variation, thus far reported only from China, of ocelot-like rosettes and spots, which looks so unlike the plain form that some taxonomists have considered it a separate species (Weigel 1961, Leyhausen 1979). Pocock (1939a) classified the patterned form as a distinct subspecies of golden cat (*C.t. tristis*) from Sichuan and Tibet, but B. Tan (*in litt.* 1991) reports that these forms have been collected from many areas of China. Adults weigh 8.5-15 kg, with males notably larger than females (Lekagul and McNeely 1977, Tan 1984). The terminal half of the tail has a whitish streak on the underside.

Very little is known of the golden cat's behavior and ecology. It is predominantly nocturnal (Griffiths 1993): Pham (1982) most often observed the species in northern Vietnam between 23-24:00 at night. It is believed to prey mainly on large rodents, but its diet also includes amphibians and insects (Le 1973), and probably also birds, small reptiles, and small ungulates such as muntjac and chevrotains. Golden cats have also been reported to prey on larger animals: the goral in the mountains of Sikkim, India (Biswas and Ghose 1982), wild pig and sambar deer in north Vietnam (Pham 1982), and young calves of domestic water buffalo (Pocock 1939a, Tun Yin 1967). Griffiths (1993) attributed two scats from Sumatra's Gunung Leuser National Park to this species, containing the remains of a rat and a muntjac.

Biology

Estrus: (C) average 6 days (n=2).

Estrus cycle: (C) 39 days (n=1) (Mellen 1989).

Gestation: (C) average 80 days (P. Andrews *in litt.* 1993).

Litter size: (C) 1.11 ± 0.11 (n=9) (Mellen 1989); range 1-3 (Guggisberg 1975, Green 1991).

Age at sexual maturity: (C) 18-24 months-females; 2 years-males (P. Andrews *in litt.* 1993).

Longevity: (C) up to 20 years (n=12) (Prator *et al.* 1988).

Habitat and Distribution

Asiatic golden cats are found in tropical and sub-tropical moist evergreen and dry deciduous forests, and have occasionally been reported from more open habitats, such as shrub and grassland (Pham 1982). In the Himalayas, the species has been recorded at elevations up to 3,050 m in Sikkim, India (Biswas and Ghose 1982) (Fig. 8).

Population Status

Global: Category 3. Regional: Category 2. IUCN: Indeterminate. There is little specific information available. The Asiatic golden cat is widely reported as uncommon and threatened by deforestation (Lekagul and McNeely 1977, Biswas *et al.* 1985, Khan 1986, R. Salter *in litt.* 1989). Like the clouded leopard, it is found throughout much of south-central China, but there have been no studies. The largest skin harvests have come from Jiangxi (234 in 1980-81), Fujian, Hunan, Sichuan, and Yunnan (Tan 1984, B. Tan *in litt.* 1991).

Protection Status

CITES Appendix I. National legislation: fully protected over most of its range. Hunting prohibited: Bangladesh, China, India, Indonesia, Malaysia (Penin.), Myanmar,

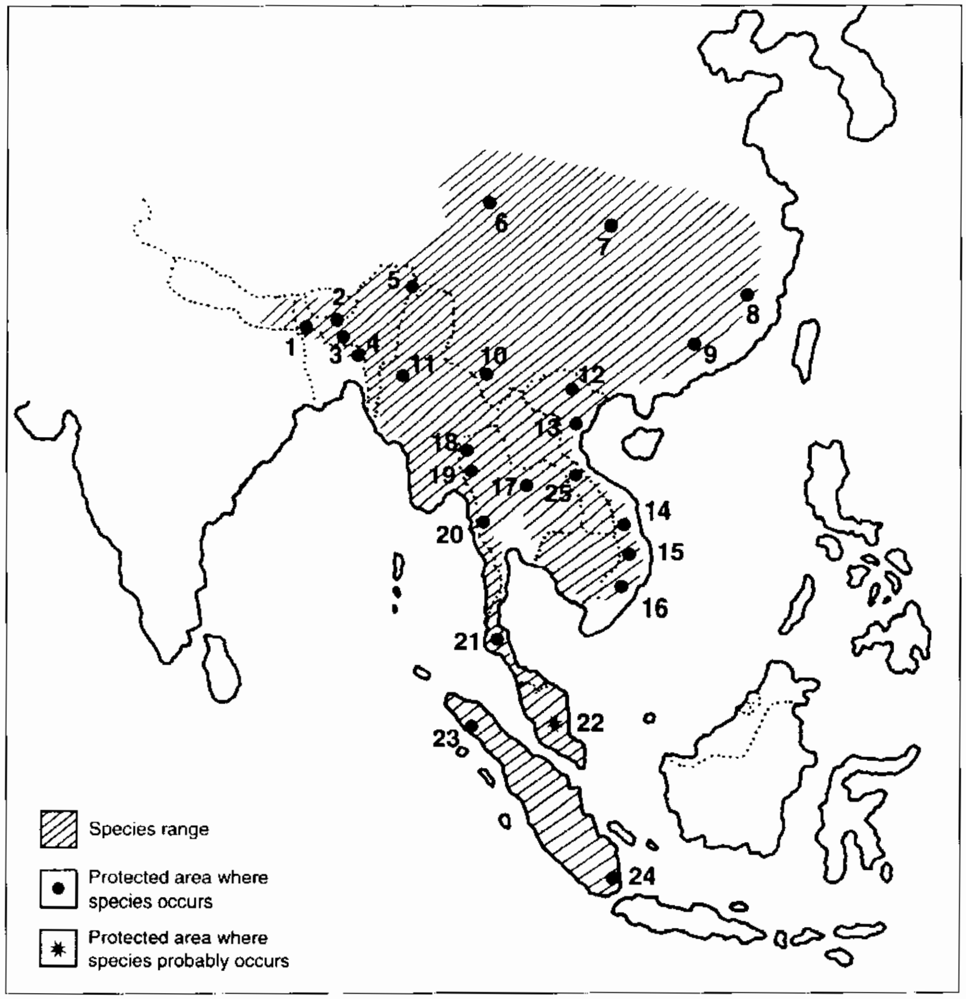

Figure 8. Distribution of the Asiatic golden cat (*C. temmincki*). 1. Gorumara Wildlife Sanctuary (India); 2. Manas IV** (India) + Royal Manas II (Bhutan) complex; 3. Balphakram II (India); 4. Rajkandi Forest Reserve (Bangladesh); 5. Namdapha II (India); 6. Wolong IV*; 7. Shennongjia IV*; 8 Wuyi Mts. IV*; 9. Babao Mt. IV; 10. Nangun River IV (China); 11. Alaungdaw Kathapa II (Myanmar); 12. Ba Be II; 13. Cuc Phuong II; 14. Kong Cha Rang IV + Kon Kai Kinh IV; 15. Yok Don IV; 16. Nam Bai Cat Tien II complex (Vietnam); 17. Nam Nao II complex; 18. Doi Chiang Dao IV; 19. Salawin IV; 20. Huai Kha Khaeng IV complex; 21. Khao Luang II (Thailand); 22. Krau IV (Malaysia); 23. Gunung Leuser II*; 24. Way Kambas IV (Sumatra, Indonesia); 25. Nakai Plateau/Nam Theun (Laos: proposed).

Nepal, Thailand, Vietnam. Hunting regulated: Laos. No legal protection outside protected areas: Bhutan, Brunei. No information: Cambodia. (Nichols *et al.* 1991; U. Ohn, R. Salter, C. Santiapillai *in litt.*).

Principal Threats

Like the clouded leopard, the golden cat is threatened primarily by deforestation, and secondarily by hunting for its pelt and bones. Livestock depredation, which usually leads to persecution, has also been reported (Prater 1971, Lekagul and McNeely 1977).

Action Planning

Projects 59 and 60.

Flat-headed cat, *Prionailurus planiceps* (Vigors and Horsfield, 1827)

Other Names

Chat à tete plate (French); Flachkopfkatze (German); gato cabeciancho (Spanish); kucing hutan, kucing dampak (Indonesia); kucing hutan (Malaysia); gaung bya kyaung (Myanmar); maew pa hua baen (Thailand).

Description and Behavior (Plate 10)

Even more than the fishing cat, the flat-headed cat appears remarkably adapted to a life of piscivory, or fish-eating (Leyhausen 1979). It has a long, sloping snout and flattened skull roof, and its unusually small ears are set well down on the sides of the head. It has large, close-set eyes which provide maximal binocular vision, and the anterior upper pre-molars are larger and sharper relative to other cats (P2 height and width: *P. bengalensis* 1.7 & 1.6 mm; *P. planiceps* 5.2 and 4.5 mm [Muul and Lim 1970]; protocone of P3 also more long and sharp than other cats of *Prionailurus:* Groves 1982). A more developed premolar is characteristic of mammals that hunt slippery prey, and provides a better grip (Lyddeker 1896). Finally, the fleshy sheaths that cover a cat's claws are shortened in the flat-headed cat, so that only about one-third of each claw is covered when retracted (Ewer 1973). While the flat-headed cat's claws do not rub against the ground when walking, they are always visible. Its toes are more completely webbed than the fishing cat's (Leyhausen 1979), and the pads are long and narrow, similar to the Bornean bay cat (Pocock 1932b). Muul and Lim (1970), commenting on the cat's feet and other features, termed it the ecological counterpart of a semi-aquatic mustelid, and Leyhausen (1979) has commented on several behavior patterns (prey capture, scent-marking) which are similar to those of both mustelids and viverrids.

The pelage of the flat-headed cat is thick and soft, and of a reddish-brown color tinged with grey, with the top of the head more brightly red. Wild adults have weighed 1.5-2.5 kg (Banks 1949, Muul and Lim 1970). The tail is very short, only 25-35% of head body length (TL=13-17 cm: Yasuma and Alikodra 1990).

The stomach contents of an adult shot on a Malaysian riverbank consisted only of fish (Muul and Lim 1970), and the stomach of a male killed on a road in a Kalimantan forest reserve contained fish scales and shrimp shells (S. Yasuma *in litt.* 1993). In Borneo, flat-headed cats are most frequently observed at night along riverbanks, hunting frogs and fish (Banks 1949; J. Payne, A. Rabinowitz *in litt.*

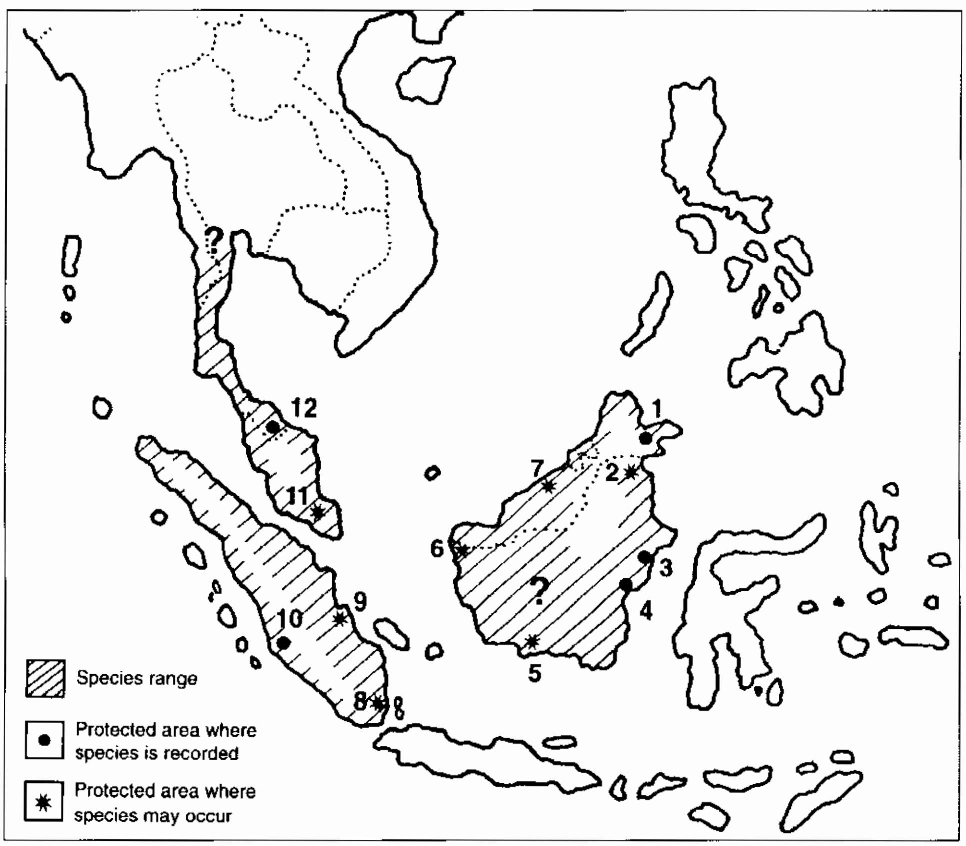

Figure 9. Distribution of the flat-headed cat (*P. planiceps*). 1. Sepilok [Mangrove] I (Sabah, Malaysia); 2. Muara Sebuka Nature Reserve (proposed); 3. Kutai II; 4. Bukit Suharto V; 5. Tanjung Puting II*; 6. Hutan Sambas Nature Reserve (proposed) (Kalimantan, Indonesia); 7. Similajau II (Sarawak, Malaysia); 8. Way Kambas IV; 9. Berbak IV; 10. Kerinci Seblat II complex (Sumatra, Indonesia); 11. Endau Rompin NP (proposed) (Peninsular Malaysia); 12. Phru Tao Dang Peat Swamp Forest protected area (Thailand: Thai Royal Forest Dept. *in litt.* 1993).

1993). In captivity, flat-headed cats enjoy a basin of water, playing or simply sitting in it for hours. They have been observed to wash objects, raccoon-style. Live fish were readily taken, with full submergence of the head, and the fish were usually carried at least two meters away, suggesting a feeding strategy to avoid letting aquatic prey escape back into water (Muul and Lim 1970; M. Rosenthal, S. Yasuma *in litt.* 1993).

Although Muul and Lim (1970) reported that their captive cat did not chase after sparrows, the cat at the Lincoln Park Zoo took live chicks (M. Rosenthal *in litt.* 1993). Banks (1949) stated that the flat-headed cat was not a poultry raider, but Guggisberg (1975) noted that the only specimen seen by ornithologist B.N. Smythies during his 20 years in Sarawak was shot while chasing chickens. In addition, M. Khan (*in litt.* 1991) reports that a female flat-headed cat was captured in Perak, Peninsular Malaysia, in a trap set to catch common civets preying on poultry.

Biology

Gestation: (C) approximately 56 days (n=1).

Longevity: (C) 14+ years (n=2) (M. Rosenthal *in litt.* 1993).

Habitat and Distribution

Most collection records for the flat-headed cat are from swampy areas, oxbow lakes, and riverine forest (C. Groves *in litt.* 1993). No research has been done on the species in the wild; for example, the only information on altitudinal range for the species (up to 700 m in the Dulit mountains of Sarawak: Hose 1893) is 100 years old. It may be less specialized than presently believed in its habitat requirements, as indicated by sightings in oil palm plantations in Malaysia, where it apparently hunts rodents (M. Khan *in litt.* 1991). It is not known north of the Isthmus of Kra (Lekagul and McNeely 1977, U. Ohn *in litt.* 1993) (Fig. 9).

Population Status

Global: Category 2. Regional: Category 1. IUCN: Insufficiently Known. The flat-headed cat is seldom encountered and is believed to be rare.

Protection Status

CITES Appendix I. National legislation: fully protected over most of its range. Hunting and trade prohibited: Indonesia, Malaysia, Myanmar, Thailand. Hunting regulated: Singapore. No legal protection: Brunei (Nichols *et al.* 1991; U. Ohn *in litt.* 1993).

Principal Threats

Water pollution, especially by oil, organochlorines, and heavy metals associated with agricultural run-off and logging activities, poses a serious threat to the flat-headed cat through contamination of its prey. This is a major problem throughout much of the flat-headed cat's range (Foster-Turley *et al.* 1990). In addition, waterways are often the areas first cleared by people as settlement expands into the forested areas (Collins *et al.* 1991).

Action Planning

Projects 61 and 62.

Rusty-spotted cat, *Prionailurus rubiginosus* (I. Geoffroy Saint-Hilaire, 1831)

Other Names

Chat rougeâtre, chat rubigineux (French); Rostkatze (German); gato rubiginosa, gato rojizo (Spanish); bitari billi (Gujarati: India); kaadu bekku (Kannada: India); pakkan (Malayalam: India); wal balalla, kolla diviya, handun diviya (Sinhalese: Sri Lanka); namali pelli (Tamil: India); kadu poona, verewa puni (Tamil: Sri Lanka).

Description and Behavior (Plate 10)

The rusty-spotted cat is the cat family's smallest member. Males weigh about 1.5-1.6 kg, and females 1.1 kg (Phillips 1935, Pocock 1939a). The coat is a short, soft fawn-grey with a rufous tinge, patterned with transverse lines of small rusty-brown spots which form solid stripes along the back of the head. The tail, which averages about 50% of head-body length, is faintly marked with dark rings (Pocock 1939a).

Very little is known of the rusty-spotted cat's behavior in the wild. They are apparently nocturnal (Chakraborty 1978, Pathak 1990, Anon. 1990c), "lying up during the hours of sunshine in a hollow log, tree or thicket in small woods of heavy timber or in thick scrub-jungles" (Phillips 1935). They climb well (Sterndale 1884), and in the wild are frequently observed in trees (Phillips 1935, Chakraborty 1978, Anon. 1990c). The diet of the rusty-spotted cat has not been properly documented; Phillips (1935) reported without elaboration that it feeds upon small mammals and birds. Local people in both Sri Lanka and India have reported that they are most visible after heavy rain, when they emerge to feed on rodents and frogs (De Alwis 1973, S. Worah *in litt.* 1993). They are known to prey on domestic poultry (Phillips 1935, Pocock 1939a, J. Zacharias *in litt.* 1992).

Biology

Length of estrus: (C) 5 days (n=1).

Gestation: 67.6 ± 2.0 days (n=4).

Litter size: 1.55 ± 0.25 (n=9) (Mellen 1989).

Habitat and Distribution

The rusty-spotted cat is found only in India and Sri Lanka. Most records are from southern India (Pocock 1939a), but there are several isolated records from the north of the country which are puzzling (Fig. 10). It is difficult to say whether distribution is continuous throughout India because the species' habitat preferences are poorly understood. In Sri Lanka, Phillips (1935) stated that "it is rarely seen far away from jungles," while De Alwis (1973) terms it "the ubiquitous wildcat of Ceylon...equally comfortable in the high montane forests of Horton Plains (2,135 m) or the sizzling sandy wastes of the Hambantota coastline." In India, Prater (1971) described its habitat as grassland, scrub and forest. However, while its presence has been confirmed in the tropical dry Gir forest (Pathak 1990, Anon. 1990c), it appears to be absent from more closed forest types. According to U. Karanth (*in litt.* 1993), it is probably not found in the tropical montane rain forest of the western Ghats. Similarly, residents of 45 villages in the Dangs semi-evergreen monsoon forest described its habitat as rocky areas and hill slopes, but not forest edges (Worah 1991).

Perhaps these seeming inconsistencies can be explained in terms of interspecific competition or ecological separation, although this subject has scarcely been investigated for the small Tropical Asian cats. The closely related leopard cat is found throughout much of India, but is absent from Sri Lanka. It is possible that the rusty-spotted cat is the more common of the two species in the drier, more open vegetation types of India, while the leopard cat predominates in the moist forests. This would explain the concentration of rusty-spotted cat records in southern India, and the infrequent and seemingly isolated reports from more northern regions. In Sri Lanka, on the other hand, the leopard cat is absent but the jungle cat occurs, and is typically found in more open habitats—grass, scrub, and open forest (Phillips 1935).

Rusty-spotted cats show some tolerance of modified habitat: females with kittens have been found denning in a tea plantation in Sri Lanka (Phillips 1935), and in the attics of houses in southern India surrounded by paddy fields and coconut plantations (J. Zacharias *in litt.* 1992). In the latter case, it was noted that the species was virtually unknown to local residents. A rusty-spotted cat was photographed in 1993 in an old farm house in a mango plantation in Bansda National Park in Gujarat (R. Wirth *in litt.* 1994). According to Karanth (*in litt.* 1993), rusty-spotted cats can be found on farmland throughout southern India's Deccan Plateau, and on the outskirts of Bangalore city.

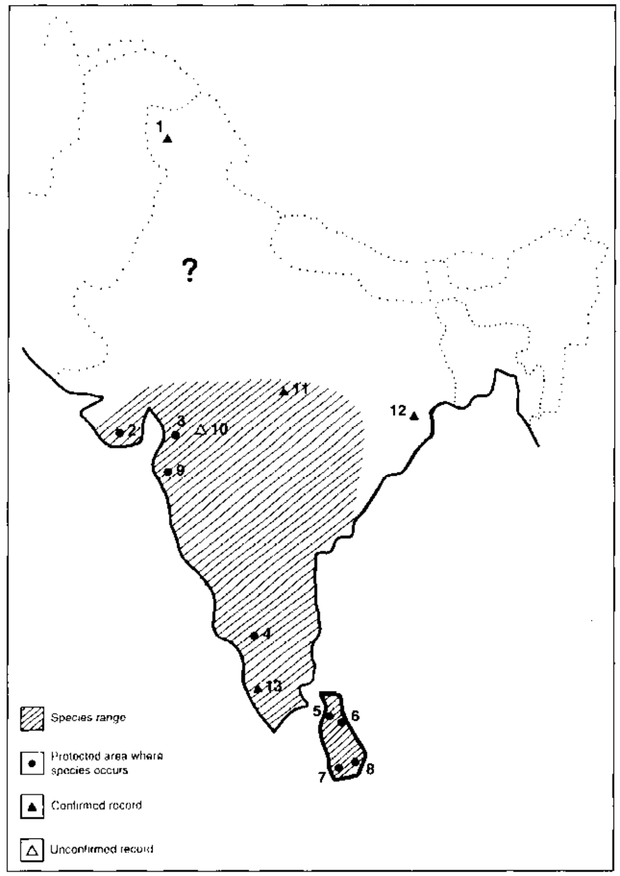

Figure 10. Distribution of the rusty-spotted cat (*P. rubiginosus*). 1. Specimen collected near Udhampur in 1975 (Chakraborty 1978); 2. Gir II complex; 3. Bansda II; 4. Nagarhole II (India); 5. Wilpattu II; 6. Flood Plains II complex; 7. Sinharaja IV#; 8. Ruhuna (Yala) II complex (Sri Lanka); 9. Borivali II; 10. Dangs Forest (Worah 1991); 11. Kittens obtained at Seone (Sterndale 1884); 12. Kitten obtained from Tuluka Reserve Forest, near Purnakat village, Angul district in 1969 (Wright 1984); 13. Rusty-spotted cats living in attics of village houses near Kochin, Kerala state, India (J. Zacharias *in litt.* 1992).

Population Status

Global: Category 3. Regional: Category 2. IUCN: Insufficiently Known. It has been described as widespread but nowhere common (Phillips 1935, Pocock 1939a, Worah 1991), as indicated by the patchy and infrequent nature of collections and observations, but this remains speculative until basic natural history studies have been carried out.

Protected Status

Indian population—CITES Appendix I; Sri Lankan population—CITES Appendix II. National legislation: fully protected over its range. Hunting and trade prohibited: India, Sri Lanka (domestic trade uncontrolled in Sri Lanka) (Nichols *et al.* 1991).

Principal Threats
Deforestation and the spread of cultivation are serious problems for wildlife in both India and Sri Lanka. As far as rusty-spotted cats are concerned, it is not known if populations can persist in cultivated landscapes, and individuals which take poultry are vulnerable to persecution (J. Zacharias *in litt.* 1992). A long coat made of rusty-spotted cat fur was found for sale in Kathmandu, Nepal (Van Gruisen and Sinclair 1992). Early reports on rusty-spotted cats refer to hybridization with domestic cats as a common occurrence (S. Worah *in litt.* 1993), but they have not been substantiated.

Action Planning
Project 63.

Fishing cat, *Prionailurus viverrinus* (Bennett, 1833)

Other Names
Chat pêcheur, chat viverrin (French); Fischkatze (German); gato pescador (Spanish); mecho biral, mecho bagh (Bangladesh); mach bagral, bagh dasha (Bengali: India); bun biral, khupya bagh (Hindi: India); kucing bakau (Indonesia); sua hay (Laos); kyaung ta nga (Myanmar); mach billi (Pakistan); kola diviya, handun diviya (Sinhalese: Sri Lanka); koddi pulli (Tamil: Sri Lanka); maew pla (Thailand).

Description and Behavior (Plate 10)
The fishing cat, with its stocky, powerful build and short legs, was given its Latin name on account of its rather viverrine or civet-like appearance (Bennett 1833). Its pelt is olive grey, and is patterned with rows of parallel solid black spots which often form stripes along the spine. Its tail is very short for a felid, less than half the body length (TL = 23-31 cm, 37% of head-body length (n=5): Pocock 1939a). Females are markedly smaller (6-7 kg) than males (11-12 kg) (Sunquist 1991). Despite its fishing habits, the fishing cat does not show marked morphological adaptations to capturing or eating fish. Like the flat-headed cat, its claw sheaths are shortened, so that the claws are not completely enveloped when retracted. Unlike the flat-headed cat, in which the second upper pre-molar is long and sharp (which enables it to grip slippery prey), the fishing cat, as in most cats, has a much smaller and less-developed tooth. Although webbed feet have often been noted as a characteristic of the fishing cat, Kitchener (1991) shows that the webbing beneath the toes is not much more developed than that of a bobcat.

The fishing cat, however, is still appropriately named, for fish have been found to be its most frequently taken prey in Nepal's Royal Chitwan National Park (D. Smith *in litt.* 1993). Fishing cats are good swimmers, and have been observed to dive into water after fish (Breeden 1989), as well as attempt to scoop them out of water with their paws (Leyhausen 1979). Other water-associated prey are probably taken as well, ranging from crustaceans and molluscs to frogs and snakes. Fishing cats also prey on rodents, small Indian civets, young chital fawns, and wild pigs (P. Sanyal *in litt.* 1991, D. Smith *in litt.* 1993), as well as domestic goats, calves, dogs, and poultry (Sterndale 1884, Phillips 1935, de Alwis 1973, Bhattacharyya 1988, Sanyal 1992). Birds are the least frequently taken prey item in Chitwan (D. Smith *in litt.* 1993). Roberts (1977) reports that in Pakistan fishing cats have been seen to catch waterfowl by swimming up to them while fully submerged and seizing their legs from underneath. A fishing cat was seen scavenging a cow carcass in India's Keoladeo National Park (Haque 1988), and in Chitwan, fishing cats have been observed to scavenge tiger kills, as well as livestock carcasses (D. Smith, pers. comm.).

Phillips (1935) noted that, in Sri Lanka, fishing cats could be met "at any hour of the day."

Biology
Reproductive season: (W) in coastal wetlands of northeastern India, peak in mating activity January-February, with births March-May, but mating also observed in June (Bhattacharyya 1992).

Gestation: (C) 63 (Ulmer 1968) - 70 days (Mellen 1989).

Litter size: (C) 2.61 ± 0.28 (n=13) (Mellen 1989); range 1-4 (Green 1991).

Age at independence: (W) 10 months (Weigel 1975).

Longevity: (C) average 12 years (K. Corbett *in litt.* 1993).

Habitat and Distribution
Fishing cats are strongly associated with wetlands. They are typically found in swamps and marshy areas, oxbow lakes, reed beds, tidal creeks, and mangrove areas. They are more scarce around smaller, fast-moving watercourses (D. Smith, pers. comm.). They have been recorded at elevations up to 1,525 m in the Indian Himalayas (Prater 1971), where they frequent dense vegetation near rivers and streams. Although fishing cats are widely distributed through a variety of habitat types (including both evergreen and tropical dry forest: Rabinowitz and Walker 1991), their occurrence tends to be highly localized.

The fishing cat also has a discontinuous distribution (Fig. 11). It has long been thought to be absent south of the Isthmus of Kra, but Van Bree and Khan (1992) reported the capture of a fishing cat in Peninsular Malaysia in 1967; it died in 1977 in Melaka Zoo. Subsequently, Melisch

(1995) drew attention to Swinhoe (1862) in which the author mentioned having examined a fishing cat from Malacca (Melaka). He gave no further details on the specimen, which may possibly have come from elsewhere. He was mistaken, moreover, in reporting the species' presence on Taiwan, a mistake still repeated in the literature over 100 years later (for example, Wang and Wang 1986). Still, it is possible that the fishing cat is present, but very rare, on the Malay peninsula. The presence of the species in Singapore, Borneo, and Bali—for which some doubtful records exist (Van Bree and Khan 1992)—deserves further investigation. There is no record of the fishing cat from China (Wang and Wang 1986), but it might be found in Guangxi or Yunnan near the border with Vietnam. In India, the fishing cat is found in the valleys of the Ganga and Brahmaputra rivers, and along the upper part of the east coast and possibly still the southwest coast, but not elsewhere in the peninsula. In Pakistan, it is mainly found along the lower reaches of the Indus River, although a few stragglers penetrate the northeast of the country along the Ravi and Sutlej rivers (Roberts 1977).

Population Status

Global: Category 2. Regional: Category 2. IUCN: Insufficiently Known. Fishing cats are locally common around wetlands. Major systems which potentially support large numbers of fishing cats include the Sundarbans mangrove forests of Bangladesh and India, the terai region along the foot of the Himalayas in India and Nepal, the floodplain of the Ganges and the Brahmaputra, Cambodia's Great Lake (Tonle Sap), the coastal floodplains of eastern Sumatra, and the deltas of the Salween, Irrawaddy, Red, Mekong, and Indus rivers (Sanyal 1983, Khan 1986; R. Salter, C. Santiapillai, C. McDougal *in litt.*). However, all of these areas have been highly affected by human activities. While fishing cats are report-

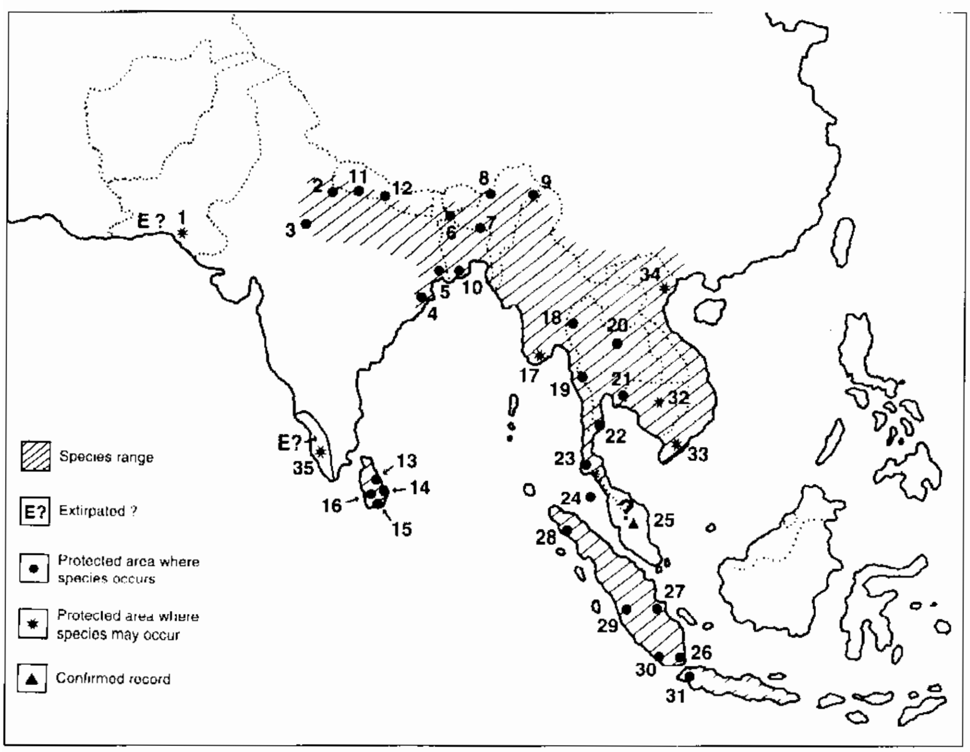

Figure 11. Distribution of the fishing cat (*P. viverrinus*). 1. Indus River delta, Keti Bunder N and S IV (Pakistan); 2. Dudhwa II; 3. Keoladeo II**; 4. Bhitar Kanika IV; 5. Sundarbans I**; 6. Jaldapara IV; 7. Balphakram II; 8. Pakhui IV; 9. Namdapha II (India); 10. Sundarbans E, S, & W IV (Bangladesh); 11. Royal Bardia II; 12. Royal Chitwan II** complex (Nepal); 13. Flood Plains II complex; 14. Maduru Oya II; 15. Bundala IV; 16. Horton Plains II complex (Sri Lanka); 17. Irrawaddy river delta (not protected) (Myanmar); 18. Salawin IV; 19. Huai Kha Khaeng IV complex; 20. Phu Hin Rong Kla II; 21. Khao Ang Ru Nai IV; 22. Khao Sam Roi Yot II; 23. Khlong Saeng IV complex; 24. Tarutao Island II (Thailand); 25. Bahau, Negeri Sembilan: first record for Peninsular Malaysia (Van Bree and Khan 1992); 26. Way Kambas IV; 27. Berbak IV; 28. Gunung Leuser II* complex; 29. Kerinci Seblat II complex; 30. Barisan Selatan II complex (Sumatra, Indonesia); 31. Ujung Kulon II (Java, Indonesia); 32. Tonle Sap [Great Lake] (not protected: Cambodia); 33. Mekong River delta (not protected); 34. Red River delta (not protected) (Vietnam); 35. Bandipur II (India) (MacKinnon and MacKinnon 1986: 240).

edly common around villages in wetland areas where habitat conversion has not been drastic, such as the outskirts of Calcutta, where the dominant land use is aquaculture (Sanyal 1992), they do not appear to be so adaptable to rice paddy and other irrigated forms of cultivation (de Alwis 1973, Dao Van Tien *in litt.* 1990, K. Mukherjee *in litt.* 1991). Along India's thickly-populated southwestern coast and in the Indus River basin in Pakistan, fishing cats are probably on the verge of extinction (U. Karanth, T. Roberts, B. Wright *in litt.* 1991, 1993).

In Java, the fishing cat appears to be restricted to small numbers in isolated coastal wetlands: there were no records during recent surveys further inland than 15 km and it must be considered critically endangered (Melisch *et al.* 1995). The habitat is threatened by human encroachment for agriculture and aquaculture, and pollution by pesticides.

D. Smith (*in litt.* 1993) recorded home range size for females in Nepal's Chitwan National Park of 4-8 km^2 (n=3); a single male had a home range of 22 km^2. Jungle cats were observed in parts of all four fishing cat home ranges.

Protection Status

CITES Appendix II. National legislation: protected over most of its range. Hunting prohibited: Bangladesh, China, India, Indonesia, Myanmar, Nepal, Pakistan (Northwest Frontier), Sri Lanka, Thailand. Hunting regulated: Laos. No legal protection: Bhutan, Malaysia, Vietnam. No information: Cambodia (Nichols *et al.* 1991; U. Ohn, R. Salter, *in litt.* 1993).

Principal Threats

Wetland destruction is the primary threat facing the species. A survey of the status of Asian wetlands found that 50% of over 700 sites were faced with moderate to high degrees of threat, including settlement, draining for agriculture, pollution, and excessive hunting, wood-cutting and fishing. Severely threatened sites include the estuaries of the Karnataka coast (southwestern India) and the deltas of the Irrawaddy, Indus, Mekong, and Red rivers (Scott and Poole 1989). In addition, clearance of coastal mangroves over the past decade has been rapid in Tropical Asia (Dugan 1993).

Action Planning

Projects 64 and 65.

Marbled cat, *Pardofelis marmorata* (Martin, 1837)

Other Names

Chat marbré (French); Marmorkatze (German); gato jaspeado (Spanish); marbal biral (Bengali: Bangladesh, India); shih mao, shihban mao, xiao yunbao [small clouded leopard] (Chinese); kucing batu (Indonesia); kucing dahan (Malaysia); kyaung tha lin (Myanmar); maew laey hin on (Thailand).

Description and Behavior (Plate 8)

The marbled cat's coat is very similar to that of the clouded leopard, although the black-edged blotches on the sides of its body are less distinct, and black spots on the limbs more numerous. It also has a long tail, equivalent to or longer than head-body length (TL = 48-55 cm: Pocock 1939a). Corbett and Hill (1993) place both species in the genus *Pardofelis*, noting that "the unique and complex pattern of the pelage is unlikely to be independently derived or primitive." Groves (1982) also supports a close relationship, noting that, like the clouded leopard, the marbled cat's upper canines are relatively enlarged. However, the marbled cat is less than one-third the weight of the clouded leopard, has a shorter, rounder skull (Pocock 1932b) and shares an identical karyotype with *Lynx*, *Panthera*, and *Uncia* (Wurster-Hill and Centerwall 1982). The evolutionary history of *marmorata* continues to be a taxonomic puzzle: Wozencraft's (1993) revision of the family Felidae concluded that the classification of the marbled cat should best be considered *incertae sedis*, or uncertain.

Very little is known of its behavior, diet, and ecological niche. It is believed to be primarily nocturnal. The few times marbled cats were observed in the Bukit Suharto Protection Forest in Kalimantan were in the evening between 8 and 10 p.m. (Yasuma and Alikodra 1990). However, in 1994, what is thought to be the first photo of a marbled cat in the wild was taken during daylight hours by a photo trap in Thailand's Huai Kha Khaeng Wildlife Sanctuary (K. Conforti, pers. comm.). The stomach of a specimen shot in Sabah contained remains of a small rat (Davis 1962). There was an observation around the turn of the century of a marbled cat stalking a bird in a tree (Guggisberg 1975). Squirrels have been reported in the diet (Ha Dinh Duc, Wang Yingxiang, pers. comm.). The marbled cat has proved to be an adept climber in captivity (Leyhausen 1979).

Biology

Gestation: (C) 81 days .

Litter size: (C) 1-4.

Age at sexual maturity: (C) 21 months (Green 1991).

Longevity: (C) up to 12 years (Medway 1978).

Habitat and Distribution

The marbled cat is primarily an animal of moist tropical forest, but there is only anecdotal information on the specificity of its habitat requirements. In Thailand, marbled cats were not found in dry tropical deciduous forest mosaic where a study of the carnivore community was carried out, but were known to be present in adjacent areas of more extensive mixed deciduous-evergreen forest (Rabinowitz and Walker 1991). Occurrence in secondary forest has been noted in Vietnam (Trinh 1991) and Thailand (B. Lekagul, pers. comm., cited in Humphrey and Bain 1990), and Hose (1893) noted that marbled cats were seen frequently in clearings in Sarawak, and were found more often at low elevations than in the mountains. A marbled cat was observed in a six-year-old logged forest isolate in Sabah (Johns 1989). Although most records for the marbled cat in Borneo are from dipterocarp forests, Davies and Payne (1982) observed one individual on a sandy beach stabilized with *Casuarina* trees and grass, in a remote, swampy mangrove area. Pocock (1939a: 258) reported that a specimen was captured in a chicken house on the Barito River, southern Borneo, "in a district which for miles around and for many years had been cleared of native forest and planted for rubber and cereals. The animal was living on the river cliff, which consisted of rocks overgrown with scrub and low bush."

There are few records on which to base the distribution map (Fig. 12). The sparseness of earlier records is indicated by the following examples: although Pocock (1939a) quotes Horsfield on the marbled cat's occurrence in hilly regions in Nepal, recent records consist of only a single specimen circa 1981 from Nawalpur, just to the west of Royal Chitwan National Park; it has not been recorded from the park itself (C. McDougal *in litt.* 1991).

The cat has only recently been recorded from China: a specimen was collected in China's Yunnan province in the

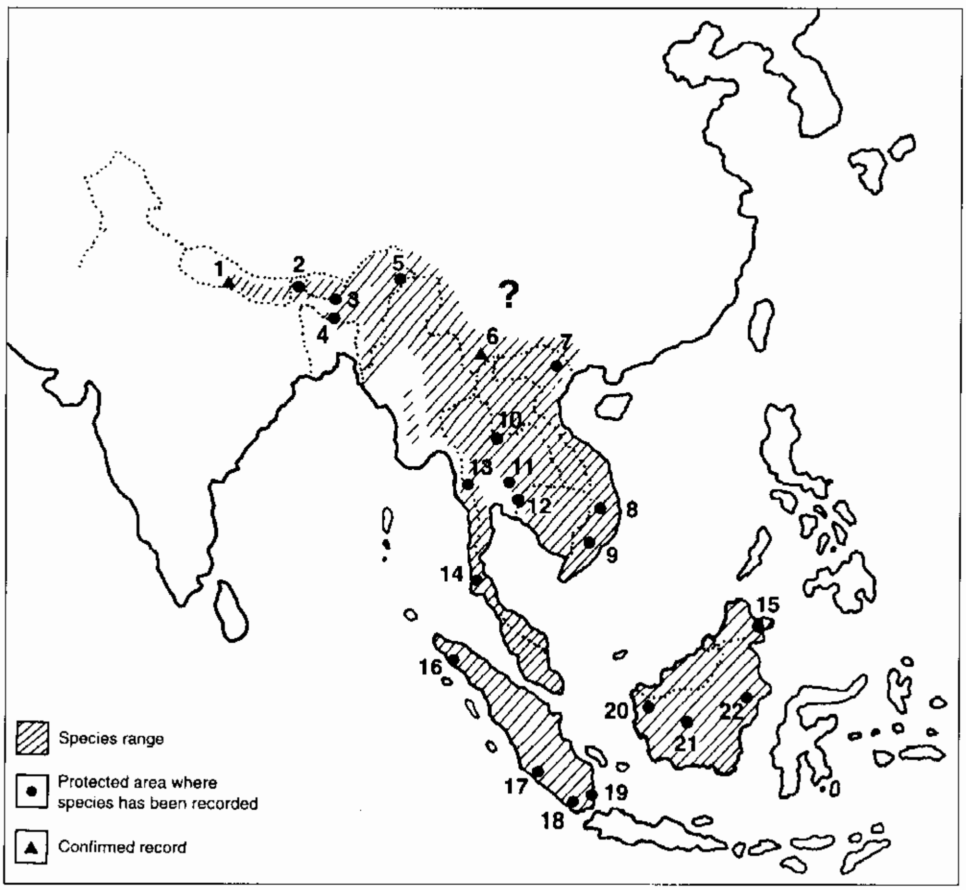

Figure 12. Distribution of the marbled cat (*P. marmorata*). 1. Specimen taken in the Nawal Parasi district in the early 1980s: only record of species occurrence for Nepal and westernmost record of species distribution (C. McDougal *in litt.* 1992); 2. Khangchengdzonga II (Sikkim, India); 3. Manas IV** (India) + Royal Manas II (Bhutan) complex; 4. Balphakram II; 5. Namdapha II (India); 6. Only record from China: specimen Shuangjiang, Yunnan province (Gao *et al.* 1987); 7. Ba Be II; 8. Yok Don IV; 9. Nam Bai Cat Tien II (Vietnam); 10. Phu Luang IV; 11. Khao Yai II complex; 12. Khao Soi Dao IV + Khao Khitchakut II; 13. Huai Kha Khaeng IV complex; 14. Khlong Saeng IV complex (Thailand); 15. Kalumba VIII (Sabah, Malaysia); 16. Gunung Leuser II* complex; 17. Kerinci Seblat II complex; 18. Barisan Selatan II complex; 19. Way Kambas IV (Sumatra, Indonesia); 20. Gunung Penrisen/Gunung Niut Game Reserve; 21. Bukit Raya I; 22. Bukit Suharto V (Kalimantan, Indonesia).

1970s (Wang and Wang 1986), and B. Tan (*in litt.* 1991) writes that there are new reports of its presence in neighboring Guangxi province. Although some distribution maps have excluded much of southeast Asia (e.g., Sunquist 1991, Corbett 1993) from the marbled cat's range, it is present in the lowland forests of southern and central Vietnam (Van Peenen 1969; Dao Van Tien, C. Santiapillai *in litt.* 1991). Husain (1974) thought it occurred in the Chittagong hill forests of Bangladesh, but Khan (1986) states that there are no actual records. In India, the species appears to be restricted to the eastern Himalayan foothills between 1,500-3,000 m altitude, associated with moist deciduous and semi-evergreen forest habitats (Biswas and Ghose 1982, Banerjee 1984).

Population Status
Global: Category 3. Regional: Category 2. IUCN: Insufficiently Known. The marbled cat may be a naturally rare species. On the other hand, 50 years ago, Pocock (1941: 476) ascribed the rarity of observation to its forest habitat and nocturnal habits rather than to real scarcity. Arboreality can also be added to the factors mitigating against sightings and collection. A field study is long overdue.

Protection Status
CITES Appendix I. National legislation: protected over parts of its range. Hunting prohibited: Bangladesh, China (Yunnan only), India, Indonesia, Malaysia, Myanmar, Nepal, Thailand. Hunting regulated: Laos, Singapore. No legal protection outside protected areas: Bhutan, Brunei. No information: Cambodia, Vietnam (Nichols *et al.* 1991; U. Ohn, R. Salter *in litt.*; China Cat Specialist Group meeting 1992).

Principal Threats
The degree of forest clearance the species can tolerate needs investigation (see Part II Chapter 1). The marbled cat is probably opportunistically hunted, but specimens are not commonly observed in local wildlife markets (Low 1991, TRAFFIC Southeast Asia *in litt.* 1993).

Action Planning
Projects 59 and 66.

Leopard, *Panthera pardus* (Linnaeus, 1758)

Other Names
Panther (English); léopard, panthère (French); Leopard, Panther (German); leopardo, pantera (Spanish); chita bagh, jhingfule bagh (Bengali: Bangladesh, India); jin qian bao, hei bao (melanistic) (Chinese); baghera, tendwa, (Hindi: India); macan tutul, macan bintang, macan kumbang (melanistic) (Indonesia); khopi (Korean); sua dok, sua dao (Laos); puli (Malayalam: India); harimau bintang, harimau kumbang (melanistic) (Malaysia); bars (Russian); kotiya (Sinhalese: Sri Lanka); puli (Tamil: India, Sri Lanka).

Description and Behavior (Plate 8)
See main species account under *Sub-Saharan Africa*. Melanistic (black) leopards are fairly frequent in populations from the tropical regions in Asia. Although numerous subspecies have been described (Pocock 1930, Shoemaker 1993) in the region, it is the Amur leopard (*P.p. orientalis*) which shows the strongest and most consistent divergence in pattern. Leopards from this region (Amur river basin and mountains of northeastern China and the Korean peninsula) have pale cream-colored coats (particularly in winter), and large (5 x 5 cm on the flanks), widely spaced (up to 2.5 cm) rosettes with thick, unbroken rings and darkened centers (Pocock 1930, Bürger 1970, Wirth 1990b). Leopards from northern China and the Himalayas also have large rosettes and pale winter coats, but the rosettes tend to be slightly smaller, more closely set, and thinner-edged (Pocock 1930, Dobroruka 1964, 1969; C. Groves, R. Wirth *in litt.* 1991).

The following weights have been recorded for leopards in the region. Five adult female leopards from China (Sichuan, Anhui and Jilin) weighed an average of 32 kg (Hu and Wang 1984, Gao *et al.* 1987, Wang 1990); three female Amur leopards weighed 25, 29 and 43 kg (Gao *et al.* 1987). Male Amur leopards have weigh 32-48 kg, with exceptionally large males up to 60-75 kg (Ognev 1935, Heptner and Sludskii 1972). Females from Sri Lanka averaged 29 kg (n=7: Pocock 1939a); males from Sri Lanka averaged 56 kg, with the largest being 77 kg (Phillips 1935, Pocock 1939a). In western Thailand, two male leopards weighed 60 and 70 kg (Rabinowitz 1989). Two males from central India weighed 50 and 70 kg (Pocock 1939a).

As elsewhere in their range, the leopards of tropical Asia have a varied diet (including the occasional young giant panda: Schaller *et al.* 1985), but show a preference for small to medium sized ungulates. Major prey species include muntjac (Java: Santiapillai and Ramono 1992; Thailand: Rabinowitz 1989), chital deer (India: Johnsingh 1983; Sri Lanka: Muckenhirn and Eisenberg 1973; Nepal terai: Seidensticker *et al.* 1990), mountain goats (Pakistan Himalaya: Schaller 1977), roe and sika deer (Ussuri region, Russia: Abramov and Pikunov 1974, Korkishko and Pikunov 1994), hog deer (Nepal terai: Seidensticker *et al.* 1990), tufted deer (Wolong, China: Schaller *et al.* 1985, Johnson *et al.* 1993b), and langur (south India: U. Karanth, pers. comm). However, Johnson *et al.* (1993b) found a shift over a seven year period in Wolong from tufted deer to bamboo rats, although they were not certain whether the shift reflected individual prey preferences of different leopards, a decrease in deer, an increase in bamboo rats, or an increase in the vulnerability of the rats due to a bamboo die-off.

Where tigers are present, the much smaller leopards tend to be few (Schaller 1967, 1972; M.K. Ranjitsinh, pers. comm.). This is not a strict rule; Korkishko and Pikunov (1994) concluded that an increase in the number of tigers in Russia's Kedrovaya Pad Reserve did not affect the leopard population. In Nepal's Chitwan National Park, leopards and tigers coexist by hunting at different times and for different prey, as well as by utilizing different vegetation complexes (Seidensticker 1976). The leopard takes smaller prey (generally less than 75 kg: Seidensticker 1976, Johnsingh 1983), in a manner similar to the food resource partitioning found for lions and leopards in the Serengeti (Bertram 1982) and the Gir Forest (R. Chellam *in litt.* 1993). Leopards are more tolerant than tigers of temperature extremes and dry environments (Santiapillai and Ramono 1992)—for example, they are more common in seasonally dry tropical monsoon forest than tigers, which are dependent upon permanent water sources (Kleiman and Eisenberg 1973, Sunquist 1981, Johnsingh 1983, Rabinowitz 1989).

Rabinowitz (1989) found a relatively high proportion of primate remains (12%) in 237 leopard scats analyzed from Thailand's Huai Kha Khaeng Wildlife Sanctuary. Big cats prefer not to hunt primates when alternative, more accessible prey species are available and abundant (Seidensticker 1983), and the relatively high rate of predation found by Rabinowitz may be due to competition with tigers for muntjac. In the dry deciduous forest of Huai Kha Khaeng, the canopy is relatively open and primates may necessarily have to do more travelling on the ground (Rabinowitz 1989). Pocock (1939a) describes leopards catching langur monkeys by feigning a move to climb a tree, leading them to jump to the ground to escape, where they could be more easily caught. Observation of the way langur troops leap in all directions between ground and trees when alarmed suggests that the monkeys may have developed a technique to confuse the leopard (P. Jackson, pers. comm. 1993).

Average daily movement for a radio-collared adult male in Thailand was 2 km, and he was active 66% of the day. There was no strong trend towards either nocturnal or diurnal activity (Rabinowitz 1989). Leopards tend to be more nocturnal in proximity to human settlement (A. Johnsingh *in litt.* 1993).

Biology

Reproductive season: (W) Seasonal throughout the region except the tropics (Prater 1971). Amur leopards have been observed to breed in June-July (summer) and give birth in September-October (Shibnev 1989). In Sri Lanka, breeding is believed to take place during the dry season (May-July) (Santiapillai *et al.* 1982). In the Himalayas, mating may take place mainly in winter, as rasping calls are heard more often at this time (A. Johnsingh *in litt.* 1993).

Age at independence: (W) 12-18 months (Eisenberg and Lockhart 1972, Muckenhirn and Eisenberg 1973, Sunquist 1983, Pikunov and Korkishko 1989).

Age at first reproduction: (W) 2-3 years (Sunquist 1983, Pikunov and Korkishko 1989).

Interbirth interval: (W) average 20-21 months (n=6: Royal Chitwan NP).

Mortality: (W) Seidensticker *et al.* (1990) found high juvenile mortality among leopards living at the edge of Royal Chitwan NP: mean litter size when cubs were up to one-third of adult size was 2.3 (n=3), but for cubs at one-half to two-thirds adult size it was 1.3 (n=6).

Habitat and Distribution

The region encompasses a broad spectrum of environments, and leopards occur in most of them (Fig. 13). Leopards are found throughout the Indian sub-continent with the exception of deserts, the Sundarbans mangroves, and densely settled areas (Khan 1986, Johnsingh *et al.* 1991)—although they occur on the outskirts of Bombay adjoining Borivli National Park (P. Jackson, pers. comm.). Leopards range throughout most of China as well (Tan 1984, Wang and Wang 1986, Gao *et al.* 1987, Ma Yiqing *in litt.* 1993). In the Himalayas, leopards are sympatric with snow leopards up to 5,200 m (Jackson 1984), although they more commonly live below the tree line (Roberts 1977, Green 1987).

In Indonesia, leopards are found only on Java and the tiny offshore island of Kangean; fossil remains date to about one million years ago (Hemmer and Schutt 1973). Van Helvoort *et al.* (1985) suspect that the leopard was introduced to Kangean Island, which is situated further from Java than Bali, where leopards do not occur. Seidensticker (1986) speculates that leopards (and tigers) are probably absent from the island of Borneo due the lack of a large ungulate prey base, and that leopards were "squeezed out" from the islands of Bali by the presence of tigers, and from Sumatra by an abundance of other felids (seven species).

For a big cat, the leopard is remarkably persistent in the face of human settlement, especially considering the high human population densities found throughout much of this region. P. Jackson (pers. comm. 1995) saw a leopard on the outskirts of Pakistan's capital, Islamabad. They are still found (in low numbers) throughout Java—despite

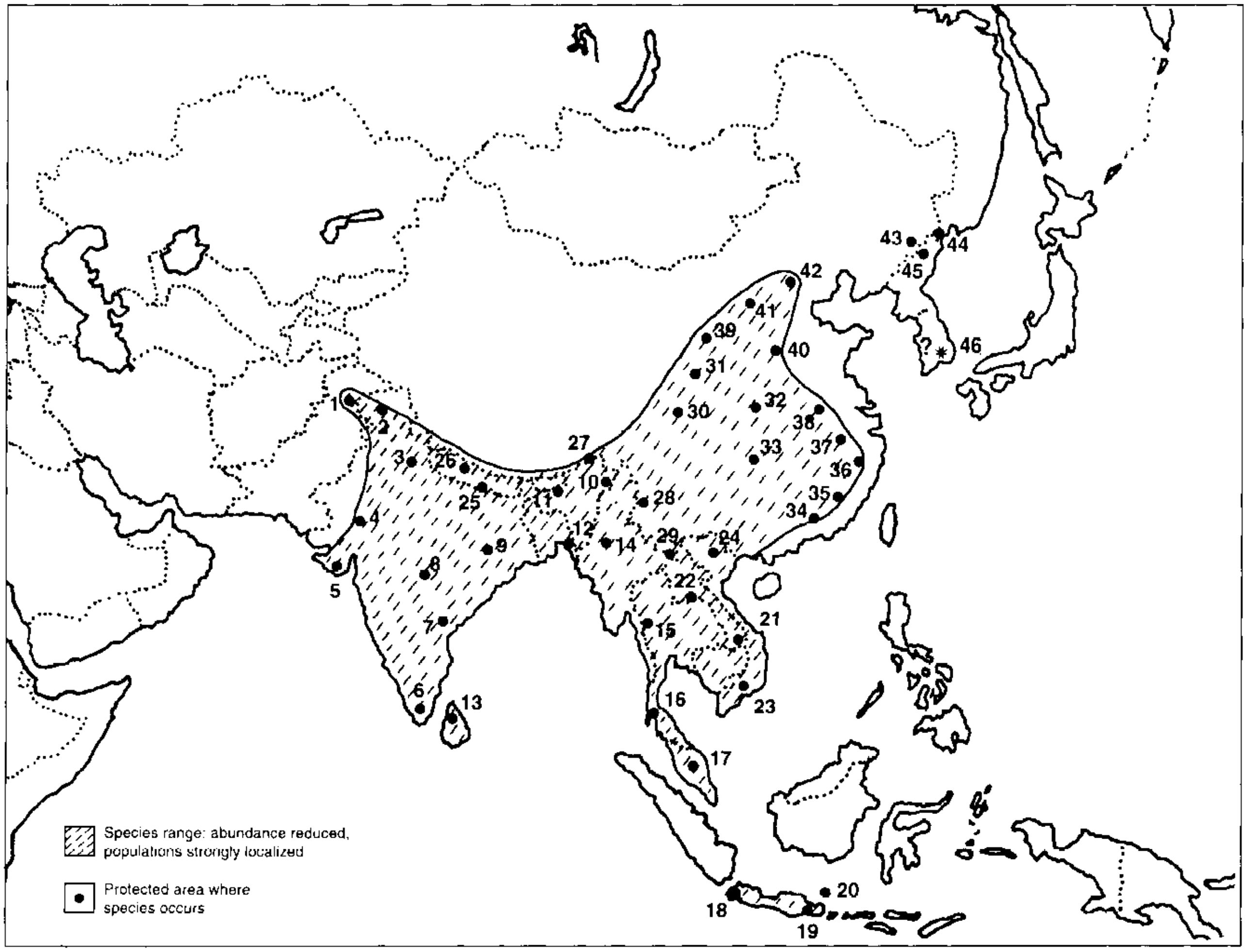

Figure 13. Distribution of the leopard (*P. pardus*) in tropical and east Asia. 1. Margalla Hills V (Pakistan); 2. Kishtwar II; 3. Corbett II; 4. Kumbhalgarh IV; 5. Gir II complex; 6. Anamalai IV; 7. Nagarjunasagar Srisailam IV; 8. Melghat IV; 9. Sanjay II; 10. Namdapha II (India); 11. Manas IV** (India) + Royal Manas II (Bhutan) complex; 12. Pablakhali IV (Bangladesh); 13. Wilpattu II (Sri Lanka); 14. Alaungdaw Kathapa II (Myanmar); 15. Huai Kha Khaeng IV complex; 16. Khlong Saeng IV complex (Thailand); 17. Taman Negara II (Peninsular Malaysia); 18. Ujung Kulon II; 19. Meru Betiri II (Java); 20. Pulao Kangean Game Reserve (Kangean island, Indonesia); 21. Xe Bang Nouane (proposed); 22. Phou Khao Khouay (proposed: Laos); 23. Nam Bai Cat Tien II; 24. Ba Be II (Vietnam); 25. Royal Chitwan II** complex; 26. Shey-Phoksundo II complex (Nepal); 27. Medog IV; 28. Gaoligong Mt. IV; 29. Xishuangbanna IV; 30. Wolong IV*; 31. Baishui River I; 32. Shennongjia IV*; 33. Mt. Fanjing IX*; 34. Chebaling IV; 35. Wuyi Mts. IV*; 36. Mt Jiulong IV; 37. Guniujiang IV; 38. Mazongling IV; 39. Liupan Mt IV; 40. Lipan Mt. IV; 41. Luya Mt. IV; 42. Wuling Mt. IV; 43. Changbai Mts. IV* (China); 44. Kedrovaya Pad I (Russia); 45. Mt. Paekdu IV* (North Korea); 46 Mt. Chiri V (South Korea).

the fact that the island is one of the most densely populated areas in the world.

Population Status

Global: Category 5a(A). Regional: Category 3(A). IUCN: Amur leopard subspecies *orientalis* and Sri Lankan subspecies *kotiya* Endangered; North Chinese leopard *japonensis* Vulnerable; Javan leopard *melas* Indeterminate. Seidensticker (1986) suggests that leopards have increased throughout the region as tigers have declined. Leopards are better able to survive outside protected areas, but in most cases populations can be expected to show a declining trend due to habitat loss, depletion of prey, and direct hunting. Leopards are now confined to one isolated habitat block in Bangladesh (Khan 1986), and have been greatly reduced in the mountains of northern Pakistan (Roberts 1977). Santiapillai *et al.* (1982) estimated the number of leopards in Sri Lanka at 400-600 based on densities of one adult per 20 (Clark 1901) to 30 km^2 (Eisenberg and Lockhart 1972) in remaining forest habitat. They believe that numbers have fallen by 75% since the turn of the century.

The Russian range of the Amur leopard, *P.p. orientalis*, shrank dramatically between 1970-1983, as leopards disappeared from the southern parts of the Sikhote-Alin mountains, a stronghold of the tiger, losing about 80% of their former range (Pikunov and Korkishko 1989). Just prior to their disappearance, Heptner and Sludskii (1972) had stated that the range of the Amur leopard had remained relatively stable over the past century. Another census was conducted in 1991, which documented a minor loss of range in the south since 1983 (Korkishko and Pikunov 1994: compare Figs. 14 and 15). Overall, the population has remained relatively stable over the last decade, at a very low level. Korkishko and Pikunov (1994) estimate numbers at no more than 28-31 (6-9 males [4-6 adults, 2-3 sub-adults]; 19 females [14 adults, five sub-adults]; three sub-adults of unknown sex: Korkishko and Pikunov 1994).

Amur leopards are now believed to be practically extinct in the mountainous regions of China's northernmost province, Heilongjiang (Ma Yiqing *in litt.* 1993), although some may persist in the Changbai Mountains in Jilin province along the North Korean border (D. Prynn, pers. comm. in Shoemaker 1993). In South Korea, the last record of an Amur leopard is from 1969, when a leopard was captured on the slopes of Odo Mountain, in South Kyongsang province. Tracks have been seen on the Chii and Sorak Mountains, indicating that they have not completely disappeared (Won 1988, Won Pyong-Oh *in litt.* 1993). In North Korea, Amur leopards may still survive in the northern mountains (Won 1968, Prynn 1980, Won Pyong-Oh *in litt.* 1993). Pikunov and Korkishko (1994) consider poaching to be the main factor currently limiting leopard numbers in Russia, and the Amur leopard must now be considered critically endangered.

Based on density estimates of one leopard per 10 km^2 in moderately suitable habitats and one per 5 km^2 in favorable habitats, Santiapillai and Ramono (1992) estimated the Javan population to be 350-700 animals. Its strongholds are in the protected areas shown in Fig. 13, as well as in more remote montane areas. These densities are considerably higher than Rabinowitz's (1989) estimate of one per 25 km^2 in tropical dry forest in Thailand; however, the

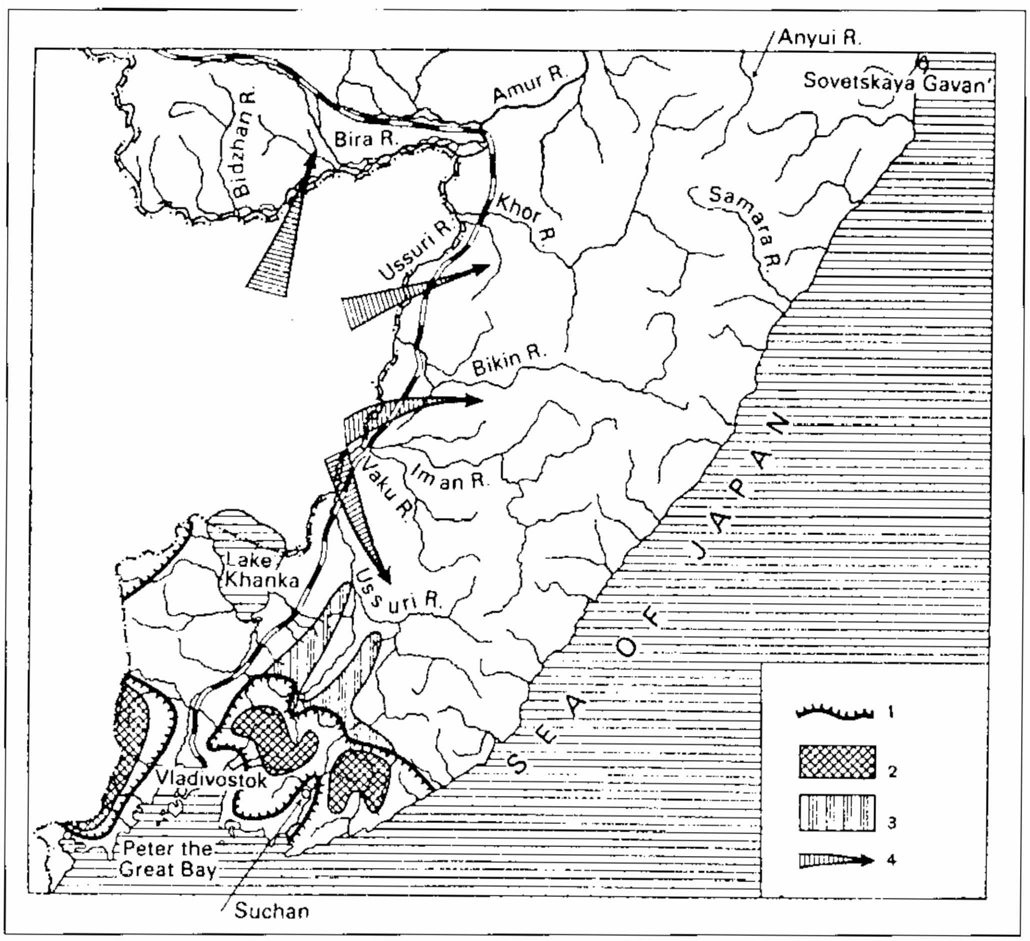

Figure 14. Distribution of the Amur leopard in Russia in 1971. S.P. Kucherenko in Heptner and Sludskii (1972: 221). 1. Boundary of region of permanent residence; 2. Best sites of habitation; 3. Region of very rare and temporary intrusions beyond zone of permanent occurrence; 4. Directions of individual intrusions from China during 1930 to 1970.

leopard may occur at higher densities in Java since the tiger's extinction in the mid-1900s (Hoogewerf 1970).

The ability of leopards to persist despite habitat loss and fragmentation is best illustrated by the case of India, where leopards have been estimated to number some 14,000, with half in protected areas (Wildlife Institute of India unpubl. data). Between 1982-1989, 170 people were killed by leopards, with the majority in the Kumaon and Garhwal hills of Uttar Pradesh, where Corbett (1948) hunted man-eating leopards in the early part of this century (Johnsingh *et al.* 1991). Leopards are also common in the foothills of the Nepalese Himalayas, despite a dense human population.

Rabinowitz (1989) found that male leopards in the Huai Kha Khaeng WS maintained slightly overlapping home ranges of 27-37 km^2, while females had ranges of 11-17 km^2 within the ranges of males. One male's home range was largest (17-18 km^2) during the early rainy season months of June and July, and smallest (4.4 km^2) during the heavy rains and floods of September and October. In Nepal's Royal Chitwan NP, Seidensticker *et al.* (1990) found similar-sized female home ranges of between 7-13 km^2. Pikunov and Korkishko (1989) reported that home ranges of Amur leopards, based on snow tracking, have been estimated at 50-300 km^2.

Figure 15. Distribution of the Amur leopard in Russia in 1991 (Korkishko and Pikunov 1994). The city of Vladivostok, shown in Figure 14, is located about 75 km southeast of the city of Ussuriisk, just off the edge of this map. 1. border of Kedrovaya Pad I; 2. border of Barsovy Special Reserve; 3. border of a proposed national park on the Shufan plateau; 4. location of leopard tracks in 1991.

Protection Status

CITES Appendix I. National legislation: fully protected over most of its range. Hunting prohibited: Bangladesh, China, India, Indonesia, Laos, Malaysia, Pakistan, Russia, Sri Lanka, Thailand. Hunting regulated: Nepal (a low level of trophy hunting was permitted until recently: C. McDougal *in litt.* 1992). No legal protection outside protected areas: Bhutan. No information: Cambodia, North Korea, South Korea, Myanmar, Vietnam (Nichols *et al.* 1990, Shoemaker 1993, R. Salter *in litt.* 1993).

Principal Threats

Leopards are threatened by a depleted wild ungulate prey base in many areas such as the Russian Far East (Korkishko and Pikunov 1994)—and are persecuted when they turn to livestock. Domestic stock has been found to be a major component of leopard diet outside protected areas (Schaller 1977, Seidensticker *et al.* 1990). Seidensticker *et al.* (1990) studied leopards living at the sharply-demarcated boundary of Chitwan NP, and concluded that the availability of domestic livestock allowed leopards to live at a higher density than could be supported by wild prey. However, high juvenile and adult mortality, coupled with suitable habitat left unoccupied for extended periods after a resident's death, indicated that the leopard population was having a difficult time maintaining its numbers due to persecution.

Illegal commercial hunting, for pelts and for bones for traditional medicine, is widespread in the region (Sayer 1983, Anon. 1986, Ma 1986, Barnes 1989, Anon. 1990b, Chazee 1990, Humphrey and Bain 1990, Low 1991, Anon. 1992g, Santiapillai and Ramono 1992, Johnson *et al.* 1993b, Korkishko and Pikunov 1994). While habitat loss is still a significant threat, the leopard does well in secondary growth, and is not as vulnerable as other felids to forest clearance (Johns 1989).

The Amur leopards of Russia are additionally threatened by the small size of the population: father-daughter and sibling matings have been observed on two occasions (Korkishko 1986). Korkishko and Pikunov (1994) found that the average litter size (measured by tracks in snow) fell from 1.75 in the winter of 1973, to 1.6-1.75 in the winter of 1983, and to 1.0 in the winter of 1991. They point out that it cannot be determined at present whether the drop is due to genetic factors, such as a decline in fertility, or is merely a demographic fluctuation.

Action Planning

Projects 67 and 68.

Jungle cat, *Felis chaus* Schreber, 1777

Other Names

Swamp cat, reed cat (English); chat des marais, chat de jungle (French); Rohrkatze, Sumpfluchs (German); gato de la jungla, gato de los pantanos (Spanish).

Tropical Asia: jongli mekoori (Assamese, India); wab, ban beral (Bengali: Bangladesh, India); conglin mao, limao (Chinese); sembalado [a cat living on the boundary of a village] (Gujarati: India); jangli billi, ban bilao, khattas (Hindi: India); kaadu bekku, bokana kotti (Kannada: India); meo pa (Laos); kattu poocha (Malayalam: India); baoga (Marathi: India); kyaung ba, taw kyaung (Myanmar); wal ballala, handun diviya (Sinhalese: Sri Lanka); kadu poona (Tamil: India, Sri Lanka); maew pa, sewa kratay (Thailand).

North Africa and Southwest Asia: bizoon el berr, qatwahshee (Arabic); chegna katu (Armenia); chel pshigi (Azerbaijan); smuncha (Dari: Afghanistan); gurbeh siah, gurbeh i kuhi (Farsi: Iran); lelianis cata (Georgian); pishik (Iraq); kamish mishiki (Kazakh); bizoon, pesheela-kaywee, pisheek-kaywee, kitkakive, kithakaywee (Kurdish); kamish suloosunu (Kyrgyz); kameshovy kot, haus (Russian); saz kedisi (Turkey); sabancha, malim (Uzbek).

Description and Behavior (Plate 10)

Like the serval, the jungle cat has long legs and a slender build. The fur is generally sandy brown, reddish or grey, and is unpatterned except for stripes on the legs and occasionally the throat, which are very light in the south of its range and darker in the north (Pocock 1951, Heptner and Sludskii 1972, Harrison and Bates 1991). The winter coat is darker and denser than in summer (Heptner and Sludskii 1972). Melanistic individuals are occasionally reported (Pocock 1939a, Chakraborty *et al.* 1988, T. Roberts *in litt.* 1993). Jungle cats have black ear tufts (up to 15 mm in length: Roberts 1977). The tail is relatively short, averaging about 40% of head-body length (TL=27 cm; n=49: Pocock 1951). Males are markedly larger than females (6.1 ± 1.5 kg [n=20] vs. 4.2 ± 1.1 kg [n=12]: Pocock 1951). An old male captured in Russia's Astrakhan reserve weighed 13 kg (Heptner and Sludskii 1972). In captivity, males are very protective of the cubs, even more so than females, and sexual dimorphism may be linked to this behavior (Schauenberg 1979, H. Mendelssohn *in litt.* 1991). Family groups—male, female and cubs—have been seen in the wild (Schaller 1967, Mendelssohn 1989). Allayarov (1964) described two jungle cat dens found along rivers in Uzbekistan: small hollows in dense reed thickets lined with old cane leaves and fur.

Jungle cats are frequently observed in the daytime. They feed primarily on rodents (Allayarov 1964, Schaller 1967, Heptner and Sludskii 1972, Roberts 1977, Khan and Beg 1986, A. Johnsingh *in litt.* 1991), including large rodents such as the introduced coypu (weight 6-7 kg) in Eurasia (Dal 1954). Heptner and Sludskii (1972) note that 200 cats were caught in traps over a period of 14 years in the vicinity of a coypu fur-farming operation. Jungle cats also take hares, birds, reptiles, amphibians, insects, and the young of larger mammals such as chital or wild pig (Rathore and Thapar 1984). They are strong swimmers, and will dive to catch fish (Mendelssohn 1989), or to escape when chased by man or dog (Heptner and Sludskii 1972). One cat in India, observed hiding in a bush while stalking a group of grey jungle fowl, appeared to make deliberate clockwise movements of its head, rustling leaves and attracting the curiousity of the birds (Tehsin and Tehsin 1990).

Biology

Reproductive season: (W) Mating behavior reported in Oct in southwestern India (A. Johnsingh *in litt.* 1991); January-February in central Asia (Allayarov 1964). Births reported in early May in Armenia (M. Akhverdian *in litt.* 1993.)

Estrus: (C) five days (Schauenberg 1979).

Gestation: (C) 63-68 days (Green 1991).

Litter size: (C) 2.89 (n=82); range 1-6.

Interbirth interval: (C) 93-131 days (Schauenberg 1979).

Age at sexual maturity: (C) 11 months (Schauenberg 1979) - 18 months (Petzsch 1968).

Longevity: (C) up to 14 years (Green 1991).

Habitat and Distribution

The jungle cat, despite its name, is not strongly associated with closed forest, but rather with water and dense vegetative cover, especially reed swamps, marsh, and littoral and riparian environments. It is able to satisfy these requirements in a variety of habitats across a wide geographic area (Fig. 16). In sandy and stony desert country (sometimes with only very sparse shrub cover: Roberts 1977), it occurs along riverbeds or near oases (Heptner and Sludskii 1972, Osborn and Helmy 1980, Harrison and Bates 1991, Belousova 1993, E. Matjuschkin *in litt.* 1993). In southeast Asia, it is typically found in tropical deciduous forest (Lekagul and McNeely 1977, Feng *et al.* 1986, Rabinowitz and Walker 1990, A. Johnsingh *in litt.* 1991), although it has also been reported from evergreen forest in central Vietnam (Trinh 1991), probably in association

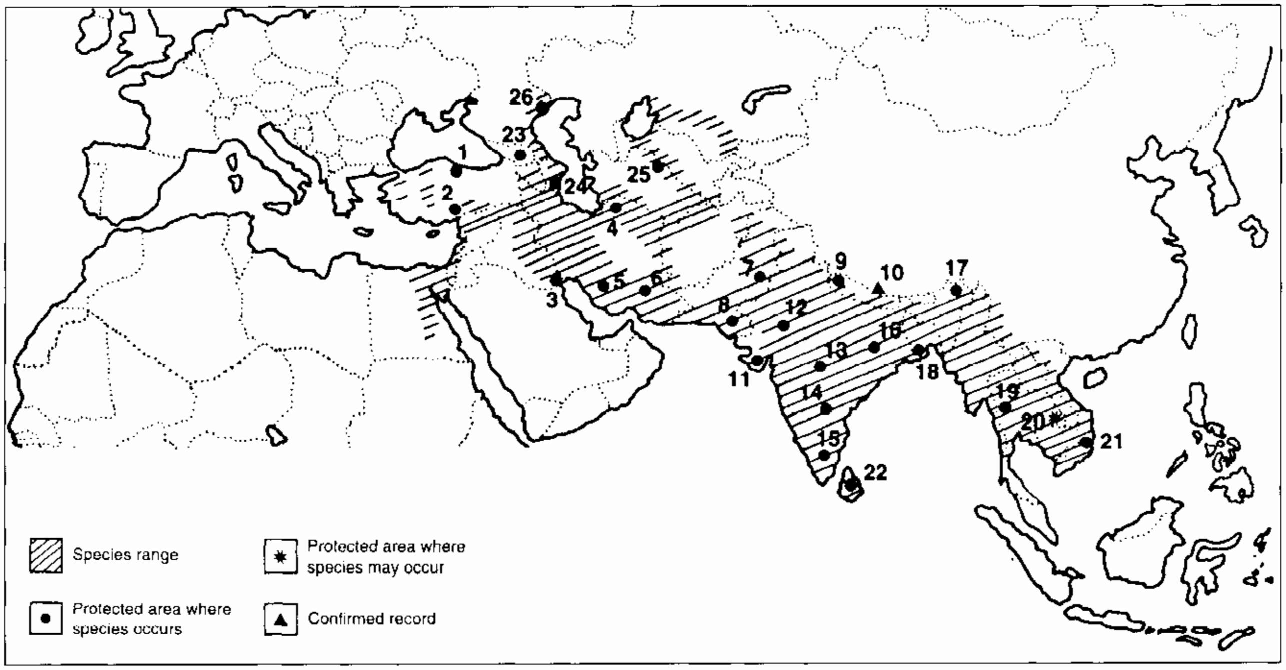

Figure 16. Distribution of the jungle cat (*F. chaus*). 1. Golardi Sulun VI; 2. Karatepe-Aslantas V (Turkey); 3. Mesopotamian marshes (not protected: Iraq); 4. Khoshyeylag I; 5. Arjan IV*; 6. Khab-o-Rouchon I (Iran); 7. Lal Suhanra V*; 8. Kirthar II (Pakistan); 9. Royal Sukla Phanta IV (Nepal); 10. Specimen collected in a river valley 50 km northwest of Mt. Everest (Feng *et al.* 1986: Tibet); 11. Gir II complex; 12. Ranthambore II; 13. Melghat IV; 14. Nagarjunasagar Srisailam IV; 15. Bandipur II; 16. Sanjay II complex; 17. Mouling II (India); 18. Sundarbans E, W & S IV (Bangladesh); 19. Huai Kha Khaeng IV complex; 20. Kaeng Tana II (Thailand); 21. Yok Don IV (Vietnam); 22. Flood Plains II complex (Sri Lanka); 23. Borzhom I (Georgia); 24. Kyzyl-Agach I (Azerbaijan); 25. Badai Tugai I (Turkmenistan); 26. Astrakhan I (Russia).

with forest clearance. It does not occur south of the Isthmus of Kra. It is also found in shrub and grassland. It has been recorded up to 2,400 m in the Himalayas (Guggisberg 1975), and up to 1,000 m in the Caucasus mountains between the Black and Caspian seas (Vereshchagin 1959). It was reported from the southeastern mountains of Algeria in the 1930s (3,000 km from the Nile River Delta in Egypt, the only place it is known to occur in Africa), but the skin, purchased in a market, was later identified by Pocock (1951) as an African wildcat (Kowalski and Rzebik-Kowalska 1991).

Jungle cats have adapted well to irrigated cultivation, having been observed in many different types of agricultural and forest plantations throughout their range, with sugarcane frequently mentioned in tropical Asia (Tikader 1983, Khan and Beg 1986, U. Karanth *in litt.* 1991, 1993). In Israel, they are commonly found around pisciculture ponds and irrigation ditches (Mendelssohn 1989). Vereshchagin (1959) noted that the cats' use of the semi-arid plains of Azerbaijan increased with development of a local irrigation system and decreased with its abandonment. However, mowing the seasonally flooded riverine *tugai* vegetation (trees and shrubs with dense stands of tall reeds and grasses) of this region for livestock fodder, as well as plowing it under for agriculture, is known to be associated with the decline of jungle cat populations in some parts of central Asia (Amudarya, Dagestan, Kalmykia, Karakalpakiya, Khorezm Oasis, northern Osetia and Syrdarya: Heptner and Sludskii 1972, Nuratdinov and Reimov 1972, Esipov 1983, Korneev and Spasskaya 1983, Kuryatnikov 1983, Belousova 1993).

Jungle cats are often spotted amidst human settlement (and are frequently reported to take chickens). Pocock (1939a) reported that jungle cats in Kashmir occupied "nearly every old building about Srinagar," and recently, in southern India, a breeding pair was found occupying an old building in an urban area, near coconut palm plantations (U. Karanth *in litt.* 1991).

Population Status

Global: Category 5b. Regional (Tropical Asia): Category 4. Regional (N Africa & SW Asia): Category 5a. IUCN: not listed. The species is widely considered common, and is probably uncommon only in countries at the edge of its range, such as China (Tan 1984, Wang and Wang 1986, Gao *et al.* 1987). In Sri Lanka as well, Phillips (1935) described the jungle cat as uncommon, and confined to the dry, open country of the north.

Density estimates from natural *tugai* habitat in central Asia range from 4-15 individuals per 10 km^2 (Belousova 1993), but where this vegetation type has declined due to development density does not exceed two cats per 10 km^2 (Nuratdinov and Reimov 1972).

Protection Status

CITES Appendix II. National legislation: protected over part of its range. Hunting prohibited: Bangladesh, China, India, Israel, Myanmar, Pakistan, Tajikistan, Thailand, Turkey. No legal protection outside protected areas: Bhutan, Georgia, Laos, Lebanon, Myanmar, Nepal, Sri Lanka, Vietnam. No information: Afghanistan, Armenia, Azerbaijan, Cambodia, Egypt, Iran, Iraq, Jordan, Kazakhstan, Syria, Turkmenistan, Tajikistan, Uzbekistan (IUCN Environmental Law Centre 1986, Nichols *et al.* 1991; A. Bukhnicashvili, U. Ohn, R. Salter, S. Umar *in litt.* 1993).

Principal Threats

Jungle cats do well in cultivated landscapes (especially those that lead to increased numbers of rodents) and artificial wetlands. However, reclamation and destruction of natural wetlands, ongoing throughout its range but particularly in the arid areas (Dugan 1993), still pose a threat to the species, as density in natural wetlands is generally higher (Allayarov 1964, Belousova 1993).

Action Planning

Project 80.

Leopard cat, *Prionailurus bengalensis* (Kerr, 1792)

Other Names

Bengal cat (English); chat léopard du Bengale (French); Bengalkatze (German); gato bengali, gato de Bangala (Spanish); chita biral, ban biral (Bangladesh); jin chien mao, bao mao, shih hu, shan mao (Chinese); psk jangley (Dari: Afghanistan); kucing batu, kucing congkok (Indonesia); chita billi (India, Pakistan); nam laniao (Kachin); huli bekku (Kannada: India); kla hla (Karen, Talain); sua meo, sua pa, sua nak (Laos); wagati (Mahratti, Ghats: India); kucing batu, rimau akar (Malaysia); kye thit, thit kyuk, kya gyuk (Myanmar); maral, tamaral (Philippines); Amurskii kot, bengalskaya koshka (Russia); hen wap (Shan); maew dao (Thailand).

Description and Behavior (Plate 10)

Leopard cats tend to yellowish-brown in the tropics and greyish-brown in the northern parts of their range (Pocock 1939a, Gao *et al.* 1987). There is a good deal of variation in the pelage: for example, Heptner and Sludskii (1972) describe the leopard cat in Russia, with its tiny range, as having greater color variation than any other Soviet felid except the lynx, which has a much wider range. The leopard cat's pelt is dotted with dark spots which are sometimes solid, sometimes rosettes, and the tail is banded with black rings toward the tip. Males (3.3-4 kg: n=6) are larger than females (2.5-3 kg: n=2) (Izawa *et al.* 1991, Rabinowitz 1990). Male leopard cats in Russia have weighed up to seven kg (Heptner and Sludskii 1972). Rodents form the principal prey (China: Wang Peichao, pers. comm to A. Abdukadir; Japan: Inoue 1972; Philippines: Alcala and Brown 1969; Russia: Stroganov 1962, Heptner and Sludskii 1972; Thailand: Rabinowitz 1990). The diet also includes young ungulates, hares, birds, reptiles, insects, eels, and fish, as well as occasional carrion (Heptner and Sludskii 1972, Santiapillai and Suprahman 1985, Gao *et al.* 1987, Yu and Wozencraft in press). Although often described as primarily nocturnal, four radio collared leopard cats in Thailand were frequently active during the day, and times of peak activity varied individually (Rabinowitz 1990).

The taxonomic status of the leopard cat is controversial, and needs re-examination, with the Iriomote cat (see next account) being the best example. Is the leopard cat a single species with pronounced geographic variation (Wozencraft 1993, Yu and Wozencraft in press), or has isolation, particularly on islands, been sufficiently lengthy to warrant species recognition for some populations? Rabor (1986) has suggested that the leopard cats of Panay, Negros, and Cebu, which are separated from the Sunda Shelf by deep water channels, may be a different and endemic subspecies of the Philippines in comparison with the population found on Palawan, which would be expected to have a closer relationship to Indonesian island populations (C. Groves, W. Oliver *in litt.* 1993). Yu and Wozencraft (in press) recognize the leopard cats of Java, Sumatra, Borneo, and Hainan as distinct subspecies, but not the cats of the Philippine Islands, which have not yet been described. Meanwhile, Heptner (1971) has argued that the leopard cat of northeastern Asia (Amur cat, *F.b. euptilura*) should be considered a separate species, but he compared it to leopard cats from southeast Asia and India. When compared to Chinese leopard cat populations, his distinctions do not hold (Gao *et al.* 1987).

Biology

Reproductive season: (W) Breeding is reported to take place once annually in the north of its range (February-March) (Ognev 1935, Stroganov 1962, Roberts 1977, Prater 1971); in the tropics, year-round (Lekagul and McNeely 1977, Santiapillai and Suprahman 1985, Gao *et al.* 1987).

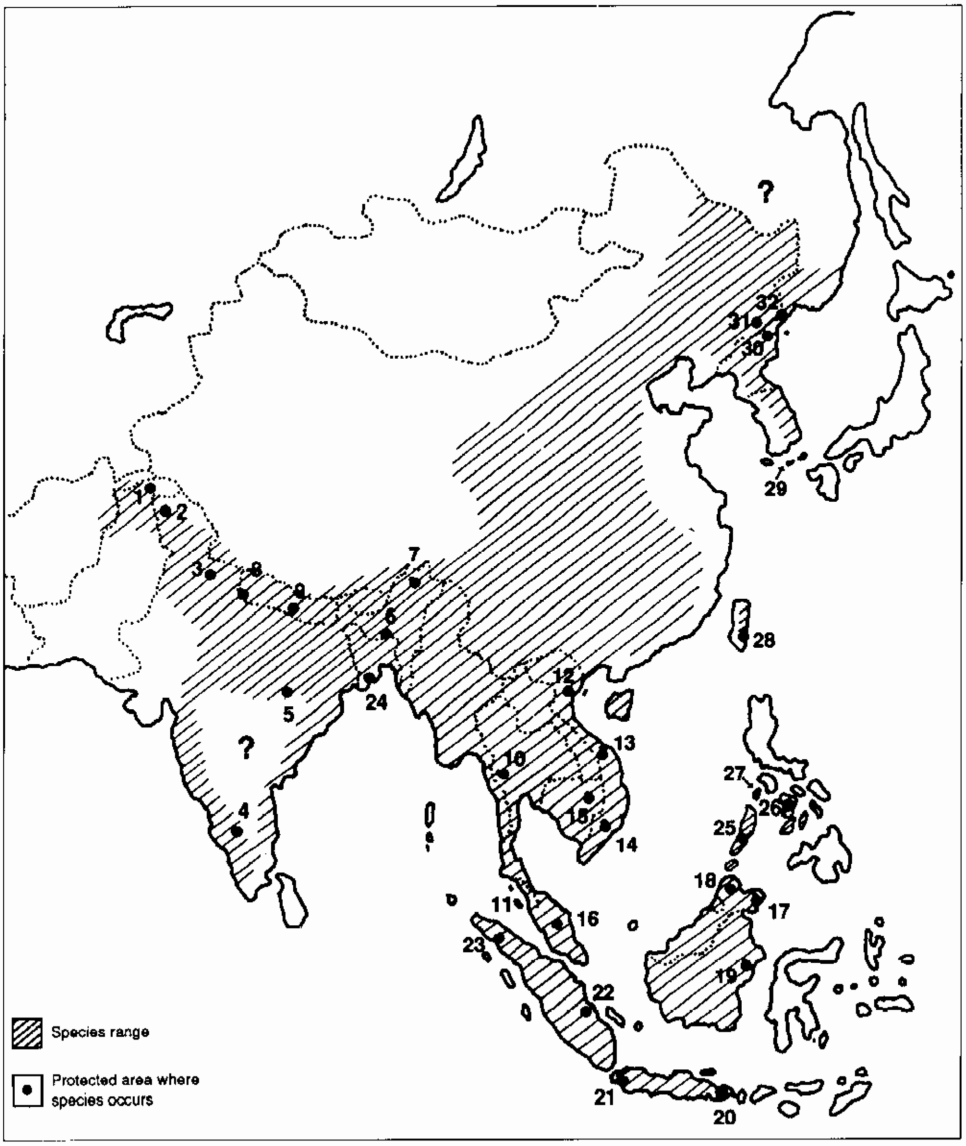

Figure 17. Distribution of the leopard cat (*P. bengalensis*). 1. Naltar IV (Pakistan); 2. Dachigam II; 3. Kedarnath IV; 4. Bandipur II; 5. Kanha II; 6. Balphakram II; 7. Mouling II (India); 8. Royal Sukla Phanta IV; 9. Royal Chitwan II** complex (Nepal); 10. Huai Kha Khaeng IV complex; 11. Tarutao II (Thailand); 12. Cuc Phuong II; 13. Bach Ma Hai Van II; 14. Nam Bai Cat Tien II (Vietnam); 15. Lomphat reserve (proposed: Cambodia); 16. Taman Negara II (Peninsular Malaysia); 17. Tabin VIII; 18. Kinabalu II (Sabah, Malaysia); 19. Kutai II (Kalimantan, Indonesia); 20. Meru Betiri II; 21. Ujung Kulong II (Java, Indonesia); 22. Berbak IV; 23. Gunung Leuser II* complex (Sumatra, Indonesia); 24. Sundarbans E, W and S IV (Bangladesh); 25. St. Paul Subterranean River II (Palawan, Philippines); 26. Panay Mts. NP (proposed: Panay, Philippines); 27. Calauit Island IV (Philippines); 28. Tawu Mts. IV (Taiwan); 29. Tsushima Islands protected area (Japan); 30. Mt. Paekdu IV* (North Korea); 31. Changbai Mts IV* (China); 32. Kedrovaya Pad' I (Russia).

Gestation: (C) 56-70 days (Nawa 1968, Hemmer 1976).

Litter size: (C,W) 1-4, usually 2-3 (Eisenberg 1981); up to eight (Heptner and Sludskii 1972).

Age at sexual maturity: (C) as early as eight months.

Longevity: (C) up to 15 years, but teeth lost at 8-10 years (P. Quillen *in litt.* 1993).

Habitat and Distribution

The leopard cat has a wide distribution in Asia, ranging up to 3,000 m in parts of its range, which extends into the Himalayas along river valleys (Habibi 1977, Feng *et al.* 1986). It occurs in a broad spectrum of habitats, from tropical rain forest to temperate broadleaf and, marginally, coniferous forest, as well as shrub forest and successional grasslands (Heptner and Sludskii 1972, Lekagul and McNeely 1977, Santiapillai and Suprahman 1985, Feng *et al.* 1986, Cai *et al.* 1989a, Ha Dinh Duc *in litt.* 1991, T. Roberts *in litt.* 1993). The northern boundaries of its range are limited by snow cover; the leopard cat avoids areas where snow is more than 10 cm deep (Formozov 1946). It is not found in the cold steppe grasslands (Ognev 1935), and generally does not occur in arid zones, although there are a few records from relatively dry and treeless areas in Pakistan (Roberts 1977). Leopard cats usually live in proximity to a water source (Gao *et al.* 1987), and can occupy refuge strips of riverine forest in areas otherwise deforested (Johns 1989: 99). They are arboreal to some extent: in Thailand, one cat was radio-located resting in a tree at a height of over 20 meters (Rabinowitz 1990).

Leopard cats occur commonly in dense secondary growth, including logged areas, and have been found in agricultural and forest (rubber tree, oil palm) plantations (Harrison 1974, Davies and Payne 1982, Santiapillai and Suprahman 1985, M. Khan *in litt.* 1991) even breeding in hill coffee plantations in southern India (U. Karanth *in litt.* 1993). Some have speculated that secondary forest may be preferred to primary forest (Banks 1949, Santiapillai and Suprahman 1985). Leopard cats can live close to rural settlements, occasionally raiding poultry, and have recently been reported from the outskirts of Beijing, where they were thought to have disappeared years ago (Tan Bangjie *in litt.* 1991).

Leopard cats are excellent swimmers (the type specimen was caught swimming in the Bay of Bengal [Pocock 1917]), and have successfully colonized offshore islands throughout their range. They are found on small islands off South Korea (Japan: Tsushima islands; S. Korea: Cheju Island), Sumatra (Santiapillai and Suprahman 1985), Thailand (Legakul and McNeely 1977, Thailand Royal Forest Dept. *in litt.* 1993), Vietnam (R. Cox, pers. comm.), China (Lu and Sheng 1986), and India (Wildlife Institute of India unpubl. data). Small islands with leopard cat populations are shaded black in Fig. 17.

Two radiotelemetry studies have produced the first data on home range size for leopard cats, although densities have not been estimated. On the Tsushima islands, Izawa *et al.* (1991) reported average home ranges of 0.83 km^2 for five males and one female. In dry tropical forest in Thailand, home range sizes for three males and one female ranged between 1.5-7.5 km^2, with core areas of 0.7-2 km^2 (Rabinowitz 1990).

Population Status

Global: Category 5b. Regional: Category 5b. IUCN: not listed. Leopard cats are common (relative to other felids) across much of their range. Island populations are the most vulnerable. In the Philippines, where the current state of the forests is arguably the worst in tropical Asia (Collins *et al.* 1991), the leopard cat is certainly in trouble (Cox 1988). It has perhaps been extirpated from Cebu, which is largely deforested, and has probably been eliminated from most of its former range on other islands (W. Oliver *in litt.* 1993). On the Tsushima islands, leopard cats are estimated to number less than 100, down from perhaps 200-300 individuals in the 1960s-1970s (M. Izawa *in litt.* 1991). On Taiwan, they are seldom caught in the traps set by aboriginal hunters (Nowell 1991).

Protection Status

CITES Appendix II; *P.b. bengalensis* CITES Appendix I; In 1985 the Chinese population of *P.b. bengalensis* was downgraded to Appendix II. In 1994 the CITES Conference of the Parties voted to downlist *P.b. bengalensis* to Appendix II for all range countries except Bangladesh, India and Thailand, whose populations remain on Appendix I. National legislation: protected over part of its range. Hunting prohibited: Bangladesh, Hong Kong, India, Indonesia, Japan, Malaysia (except Sabah), Myanmar, Nepal, Pakistan, Russia, Thailand, Taiwan. Hunting and trade regulated: South Korea, Laos, Singapore. No legal protection outside protected areas: Bhutan, Brunei, China, Philippines, Vietnam. No information: Afghanistan, Cambodia, North Korea, (Nichols *et al.* 1991; U. Ohn, R. Salter *in litt.* 1993; A. Amirkhanov, pers. comm.).

Principal Threats

The leopard cat appears to be more tolerant of deforestation and habitat alteration than other Asian felids, with the exception of the jungle cat. However, it is not invulnerable, as attested to by population declines on small islands (Izawa *et al.* 1991). Captive breeding programs are being developed for the populations on Tsushima (Japan: T. Doi *in litt.* 1993) and Negros islands (Philippines: E. Alcala, pers. comm.).

In China, the center of its range, commercial exploitation has been heavy, especially in the southwest (Yu Jinping *in litt.* 1993). Exports from China jumped in 1984, averaging roughly 200,000 skins annually through 1989 (WCMC, unpubl. data). The actual harvest is much higher: a 1989 survey of major Chinese fur companies revealed estimated stockpiles of over 800,000 pelts (Yu and Wozencraft in press). While harvests of leopard cat have been high in the past, averaging 150,000 annually from 1955-1981 (Lu and Sheng 1986), the annual take from 1985-1988 is believed to be of the order of 400,000 (Yu Jinping *in litt.* 1991). The European Community, formerly the primary destination for leopard cat pelts exported from China, imposed an import ban in 1988, and Japan became the main consumer, at a lower level, importing 50,000 skins in 1989 (Johnson and Fuller 1992). There is also a substantial domestic market (Johnson *et al.* 1993). Concern over the situation has grown. In April 1993, CITES called on Parties to refrain from importing leopard cat products from China until it had implemented a series of recommendations to control and manage the trade. A project to investigate the status of the species and to advise the Chinese government on the design of a sustainable management program is underway (Johnson and Fuller 1992, Johnson *et al.* 1993).

Leopard cats can hybridize with domestic cats, as is shown by the popular domestic breed, the "safari cat." Hybridization in the wild has been reported (Heptner and Sludskii 1972).

Action Planning

Project 13.

Iriomote cat, *Prionailurus bengalensis iriomotensis/ Incertae sedis* (Imaizumi, 1967)

Other Names

Chat d'Iriomote (French); Iriomote-Katze (German); gato d'Iriomote (Spanish); Yameneko (Japan).

Description and Behavior (Plate 10)

The Iriomote cat was first described for science in the late 1960s, when Imaizumi (1967) labelled it "probably one of the most primitive species among the Asiatic Felidae." It is found only on Iriomote island, an island of 293 km^2 at the southernmost tip of the Ryuku chain, located about 200 km east of Taiwan. Imaizumi (1967) considered the Iriomote cat to be a highly differentiated form based upon the following principal characters: the ventral border of the paraoccipital process separated from the auditory bulla; an oval disc on each side of the basisphenoid and basioccipital region; P3 with postero-external corner evenly rounded, without a cingulum cusp; and auditory bullae unusually small. These characters, however, are polymorphic in the leopard cat (Petzsch 1970, Corbett and Hill 1993).

The Iriomote cat is currently classified as a subspecies of the leopard cat (*P.b iriomotensis:* Wozencraft 1993, Yu and Wozencraft in press), albeit one "subjected to extreme selective pressure with the attendant possibility of genetic drift" (Glass and Todd 1977). However, it was originally described as a monotypic species (*Mayailurus iriomotensis:* Imaizumi 1967), and is also known as a species closely related to the leopard cat (*Prionailurus iriomotensis:* Hemmer 1978a, Leyhausen 1979, Corbett and Hill 1993). Moreover, based on skull characters, close relationships have been suggested between the Iriomote cat and the Asiatic golden cat, the Bornean bay cat (Groves 1982), and the marbled cat (Leyhausen and Pfleiderer 1994). Leyhausen and Pfleiderer (1994) also state that the Iriomote cat has incompletely sheathed and semi-retractile claws, resembling the fishing and flat-headed cats. They maintain that the Iriomote cat has more in common morphologically with other cats of the three genera *Prionailurus, Profelis,* and *Pardofelis* than with the leopard cat populations of east and southeast Asia. According to their analysis, the Iriomote cat is most properly classified as *Prionailurus iriomotensis,* although further investigation may well lead to the resurrection of the original genus *Mayailurus.*

However, while Leyhausen and Pfleiderer (1994) argue for a relatively distant relationship between the leopard cat and the Iriomote cat based on morphological characters, molecular analyses have led the investigators to conclude that the leopard cat is the Iriomote cat's closest relative (Wurster-Hill *et al.* 1987, Masuda *et al.* 1994, Suzuki *et al.* 1994). The latter two studies suggest that the Iriomote cat separated from the leopard cat less than 200,000 years ago, which coincides with the geological isolation of the Ryuku archipelago. Neither study made recommendations on whether science should consider the Iriomote cat a full species or a leopard cat subspecies, noting only that the Iriomote cat has evolved some unique morphological characters compared with the mainland leopard cat.

The repercussions that classification of the Iriomote cat has for its conservation make it an extremely important case study for reconciling the results of molecular and morphological analyses (see discussion of this issue in the research chapter). Is it the world's most endangered cat species, or rather a distinctive island population of one of the world's most common cats? A project is put forward in Part III to resolve this conundrum.

The Iriomote cat has a dusky brown pelt with rather long hair, patterned with horizontal rows of darker spots which tend to form indistinct bands. It has a relatively elongate and low-slung build, with short legs and tail (TL=19 cm, 32% of head-body length [n=3]: Imaizumi 1967). Average weight is 4.2 ± 0.5 kg for males (n=15), and 3.2 ± 0.3 kg for females (n=10) (Izawa *et al.* 1989). The diet of the Iriomote cat has been studied in detail (Yasuma 1981, 1984, 1988): 95 prey species were identified from 849 scats. Major prey species include the common rat (36%), Ryuku flying fox (16.5%), birds (brown-eared bulbul and banded crake: 7.4%), and Kishinoue skink (18.6%). A variety of insects are frequently eaten (including 39 species of beetle), but they contribute little to the diet by weight (Yamaya and Yasuma 1986). Amphibians, crabs, and fish are occasionally taken. The Iriomote cat is primarily nocturnal, partially arboreal, and swims well (Yasuma 1981).

Biology

Reproductive season: (W) Mating in February-March and September-October, based on vocalizations. Births observed only late April-May.

Gestation: (W) approx. 60-70 days.

Litter size: (W) 1-4 (Yasuma 1984, 1988).

Longevity: (C) One male kept by the Okinawa Kodomonokuni Zoo died at an age of over 10 years (T. Doi *in litt.* 1993).

Habitat and Distribution

Found only on Iriomote Island, at the southernmost tip of the Ryuku Island chain, which is part of the archipelago stretching from Kyushu to Taiwan known as Nansei Shoto (Fig. 18). Iriomote Island consists predominantly of low mountains (300-400 m) covered with sub-tropical evergreen broadleaved primary forest, including extensive belts of mangrove along waterways. The Nansei Archipelago

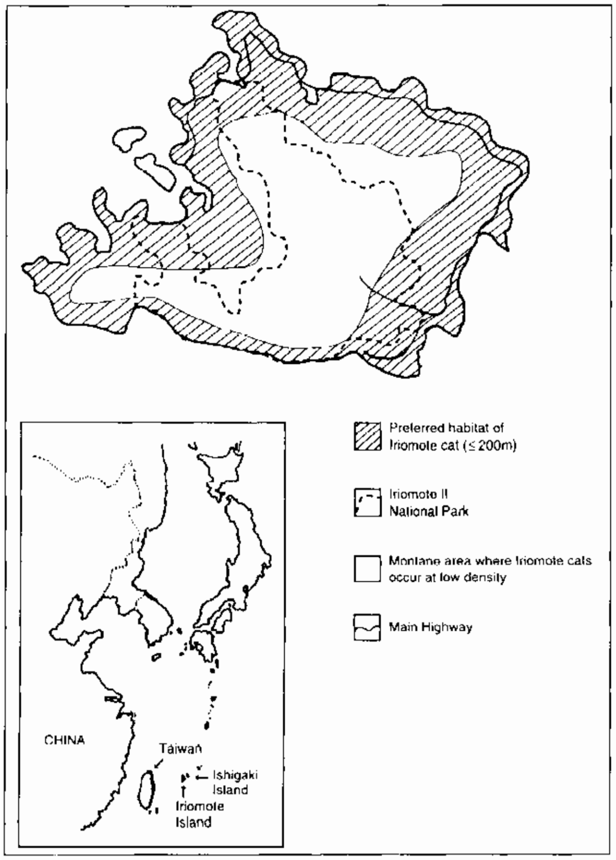

Figure 18. Distribution of the Iriomote cat (*P. b. iriomotensis*).

has a high degree of endemism, and has been termed the "Galapagos of the Orient." People came to the island only after the second World War, following spraying of DDT by the Americans to eradicate malaria (P. Leyhausen *in litt.* 1977), and by 1991 numbered around 1,500 (Izawa et. al. 1991). Settlement is concentrated mainly along the coast from the northwest to the southeast, with the center of the island being relatively undisturbed (Barber *et al.* 1984, Anon. 1992a). However, the Iriomote cat typically inhabits the low altitude coastal areas of the island alongside the human population, rather than the protected montane area at the island's center (Izawa *et al.* 1989).

Population Status

Not ranked here for vulnerability, but with its tiny range and small population size, the Iriomote cat as a full species would be in Category 1, and qualify as the world's rarest and most vulnerable cat. IUCN: Endangered. The population is estimated to number less than 100 individuals, but is thought to have remained stable since monitoring began in 1982 (Izawa *et al.* 1989).

Radiotelemetry studies carried out from 1982-1988 found that males had larger home ranges than females, at 2.96 ± 1.8 km^2 and 1.75 ± 0.8 km^2 respectively. Females showed higher residentiality, maintaining stable home ranges and using one feeding site for several years, while males tended to shift their area of activity after a period of several months. In general, male home ranges overlapped those of other males and females, while female home ranges seldom overlapped (Izawa *et al.* 1989). Density is approximately 0.34 animals per km^2 (M. Izawa *in litt.* 1993).

Protection Status

CITES Appendix II. National legislation: fully protected since 1967, but new endangered species legislation sets stronger requirements for habitat protection, and the national government is now investigating ways to expand protected area coverage (M. Izawa *in litt.* 1993). The park does not protect the most important habitat for the Iriomote cat, lowland coastal forest (Izawa *et al.* 1991: see Fig. 18). However, the Japanese government is in the process of developing a comprehensive action plan for both research and conservation (T. Doi *in litt.* 1993). The best prospect for further reserve establishment is along the western coastline, but the area has not yet been studied to determine its suitability for the Iriomote cat (M. Izawa *in litt.* 1994), and creating more reserves on Iriomote will be politically difficult.

Principal Threats

The Iriomote cat is endangered primarily because it is restricted to a single population, albeit located on the least developed island in Japan. That situation is changing rapidly, however, as island residents press for accelerated economic growth. Iriomote is promoted as a tourist location, with the Iriomote cat a major source of appeal. The industry is still nascent, but plans are being laid for major resort development, along with a dam to provide the eight projected hotels with a stable supply of water (Anon. 1992a). A major airport is being constructed on nearby Ishigaki island (20 km away) to provide a direct link to Tokyo.

While poorly planned tourist infrastructure may damage the cat's habitat, by far the major threats at present are agricultural and cattle-raising projects, which are heavily subsidized by the government (Barber *et al.* 1984, Anon. 1992a) and involve forest clearance. Conservationists' opposition to the Ministry of Agriculture's projects and their calls for legal protection of lowland habitat have further increased the local residents' impression that the Iriomote cat is an obstruction to economic development. Other important threats include road kills, competition from a growing population of feral cats, and the risk of disease transmission from these and other imported mammals (Izawa *et al.* 1991, M. Izawa *in litt.* 1993).

Action Planning

Projects 69 and 70.

Part I
Species Accounts

Chapter 4
Eurasia

Box 1
Vulnerability Index to Species of the Region (in order of vulnerability)

Asia sub-region

Species	Habitat Association St [Mar] (Tot) Score	Geog. Range (10^6 km²)	Score	Body Size Score	Total Score	Ranking
Snow leopard, *U. uncia**	I: 1 [6] (7) 0	S: 2.39	-1	L -1	-2	1(A)
Chinese mtn. cat, *F. bieti**	N: 2 [3] (5) -1	R: 0.29	-2	S +1	-2	1
Manul, *O. manul**	I: 4 [2] (6) 0	M: 5.08	0	S +1	+1	2
Asiatic wildcat, *F.s. ornata* group	I: 3 [4] (7) 0	M: 7.00	0	S + 1	+1	2
Eurasian lynx, *L. lynx**	B: 6 [5] (11) +1	W: 12.61	+1	M 0	+2	3

Key:

* Most or all of this species' range lies within the region

Habitat Association
St = number of strong + significant habitats
N = Narrow (-1); B = Broad (0)
[Mar] = number of marginal habitats
(Tot) = total number of habitats

Geographic Range
(in millions of km²)
R = Restricted (-2); S = Small (-1); M = Medium (0); W = Wide (+1)

Body Size
L = Large (-1); M = Medium (0); S = Small (+1)

(A) = Actively threatened

Regional Criteria:
Habitat association: Narrow = 5 habitat types; Intermediate = 6-7 habitat types; Broad = 11 habitat types
Geographic range: Restricted = ≤1 million km²; Small = 2-3 million km²; Medium = 5-7 million km²;
Wide = 12-13 million km²
Body size: Large = 35-135 kg; Medium = 7-20 kg; Small = ≤6.5 kg

Continued on next page

Europe sub-region

Species	Habitat Association St [Mar] (Tot) Score	Geog. Range (10^6 km²)	Score	Body Size Score	Total Score	Ranking
Iberian lynx, *L. pardinus**	I: 3 [3] (6) 0	R: 0.08	-2	M 0	-2	1
European lynx, *L. lynx*	I: 5 [1] (6) 0	S: 0.95	-1	M 0	-1	2
European wildcat, *F.s. silvestris* group	I: 4 [2] (6) 0	S: 1.67	-1	S +1	0	3

* All of this species' range lies within the region

Regional Criteria:
Habitat association: Intermediate = 6 habitat types
Geographic range: Restricted = <0.5 million km²; Small = 0.5-2 million km²
Body size: Large = 35-135 kg; Medium = 7-20 kg; Small = ≤6.5 kg

See the Introduction to the Species Accounts for explanation of the vulnerability ranking system (pp. 2-6).

Asia Sub-region

Snow leopard, *Uncia uncia* (Schreber, 1778)

Other Names

Ounce (English); panthère des neiges, léopard des neiges, once (French); Schneeleopard, Irbis (German); leopardo nival, pantera de las nieves (Spanish); xue bao (Chinese); palang-i-berfy (Dari: Afghanistan); bharal hc, barfani chita (Hindi, Urdu: India, Pakistan); shan (Ladakhi: India); hiun chituwa (Nepal); Ikar (Pakistan); irbis, irvis (Russia, Central Asian republics, Mongolia); snezhnai bars (Russian); sarken (Tibetan); chen (Bhutan).

Description and Behavior (Plate 11)

The snow leopard exhibits superb camouflage for its mountain environment of bare rocks and snow, being whitish-grey (tinged with yellow) in color, and patterned with dark grey rosettes and spots. Further adaptations for high altitude life include an enlarged nasal cavity, shortened limbs (adult shoulder height is about 60 cm), well-developed chest muscles (for climbing), long hair with dense, woolly underfur (belly fur grows as long as 12 cm), and a tail up to one meter long, 75-90% of head-body length (Hemmer 1972, Fox 1989, Jackson 1992). Snow leopards molt twice a year, but the summer coat differs little from the winter in density and length (Heptner and Sludskii 1972). The long tail is thought to aid balance, and snow leopards will wrap their tails around themselves when lying or sitting for added warmth. The snow leopard's vocal fold is less developed than in the pantherines, lacking a thick pad of fibro-elastic tissue, so that it cannot make the low and intense "roars" of which the other big cats are capable (Hemmer 1972, Peters 1980, Hast 1989). Males are larger than females, with average weights between 45-55 kg as opposed to 35-40 kg for females (Jackson 1992).

A. Kitchener (*in litt.* 1993) has suggested that the snow leopard, for which two subspecies have been described (Stroganov 1962) but are not generally recognized (e.g., Hemmer 1972, Wildt *et al.* 1992a), is a prime candidate for subspeciation because of the insular and patchy nature of its high mountain habitat. Similarly, Fox (1994) draws attention to the gap between the main southern snow leopard population and the northern population in Russia and Mongolia, and suggests that the two populations may differ genetically. On the other hand, instances of snow leopards migrating up to 600 km have been reported from the former U.S.S.R. (Heptner and Sludskii 1972, Koshkarev 1990; Fig. 1).

Snow leopards are opportunistic predators capable of killing prey up to three times their own weight (Schaller 1977, Jackson and Ahlborn 1988, Fox 1989), with the exception of fully grown yak or wild ass. They will also take small prey: in China's Qinghai province, Schaller *et* *al.* (1988a) found that 45% of their summer diet consisted of marmots. In general, their most commonly taken prey consists of wild sheep and goats (including blue sheep, Asian ibex, markhor, and argali), but also includes pikas, hares, and gamebirds (chukor partridge and snowcocks) (Hemmer 1972, Heptner and Sludskii 1972, Schaller 1977, Jackson 1979, Mallon 1984a, Schaller *et al.* 1987, 1988a, Fox 1989). Jackson and Ahlborn (1984) estimated a snow leopard's annual prey requirements to be of the order of 20-30 adult blue sheep. In a study of radio-collared animals, Jackson and Ahlborn (1988) found that adult snow leopards killed a large prey animal every 10-15 days, and remained on the kill for an average of 3-4 days, and sometimes up to a week. Snow leopards tend to remain within a relatively small area for 7-10 days, then shift activity to a relatively distant part of their home range. Daily distances moved were up to seven km, but averaged one km for males and 1.3 km for females (Jackson and Ahlborn 1988).

Predation on livestock can be significant (Schaller 1977, Mallon 1984a, Fox and Chundawat 1988, 1991a, Schaller *et al.* 1988a,b, Chundawat and Rawat 1994, Oli 1994, Jackson *et al.* 1994), with stock losses on the Tibetan Plateau averaging about 2% per village, but up to 9.5% in some "hotspots" (Jackson *et al.* 1994). Oli *et al.* (1994) analyzed 213 scats of snow leopards living around villages within Nepal's Annapurna Conservation Area, and found livestock remains in 17.8%. The proportion increased to 39% in winter, probably in relation to marmot hibernation, deep snow, and a tendency for yak to be less widely dispersed at this time. Snow leopards in this area took livestock despite the availability of blue sheep in relatively high numbers (Oli 1991).

Biology

Reproductive season: (W) early January to mid-March, a time when vocalizations can most commonly be heard (Jackson and Ahlborn 1988). (C) same; most births occur in May-June (Freeman 1975, 1977, Blomqvist and Sten 1982).

Estrus: (C) 2-12 days (Rieger 1984).

Estrus cycle: (C) 15-39 days (Freeman 1975).

Gestation: (C) 98-104 days (Jones 1977, Freeman 1975).

Litter size: (C,W) 1-5, usually 2-3, exceptionally up to seven (Heptner and Sludskii 1972, Blomqvist and Sten 1982, Wharton and Freeman 1988).

Age at dispersal: (W) 18-22 months; sibling groups may remain together briefly upon independence (Jackson and Ahlborn 1989).

Age at sexual maturity: (C) 2-3 years.

Age at last reproduction: (C) 15 years.

Longevity: (C) up to 21 years (Blomqvist and Sten 1982, Wharton and Freeman 1988).

Habitat and Distribution

As shown in Fig. 1, the snow leopard has an extremely patchy and fragmented distribution, consisting of a mix of long narrow mountain systems and islands of montane

Table 1
Distribution and Population Estimates for Snow Leopard (Fox 1994)

Country	Area of Habitat (km²)	Estimated Population	Literature Source
Afghanistan	50,000	100 - 200	Map-based estimates (low density)
Bhutan	15,000	100 - 200	Map-based estimates (moderate density)
China	1,100,000	2,000 - 2,500	Schaller 1990, Jackson 1992
India	75,000	200 - 600	Chundawat *et al.* 1988, Fox *et al.* 1991a
Kazakstan	50,000	180 - 200	Annenkov 1990, Zhirjakov 1990
Kyrgyzstan	105,000	800 - 1,400	Zhirjakov 1990, E. Koshkarev, pers. comm.
Mongolia	90,000	500 - 1,000	Green 1988, Schaller *et al.* 1994
Nepal	30,000	350 - 500	R. Jackson, pers. comm.
Pakistan	80,000	100 - 200	Schaller 1976, 1977
Russia	130,000	50 - 150	Smirnov *et al.* 1990, E. Koshkarev, pers. comm.
Tajikistan	100,000	120 - 300	Sokov 1990, Buzurukov, pers. comm.
Uzbekistan	10,000	10 - 50	Braden 1982, E. Koshkarev, pers. comm.
Total	1,835,000	4,510 - 7,350	

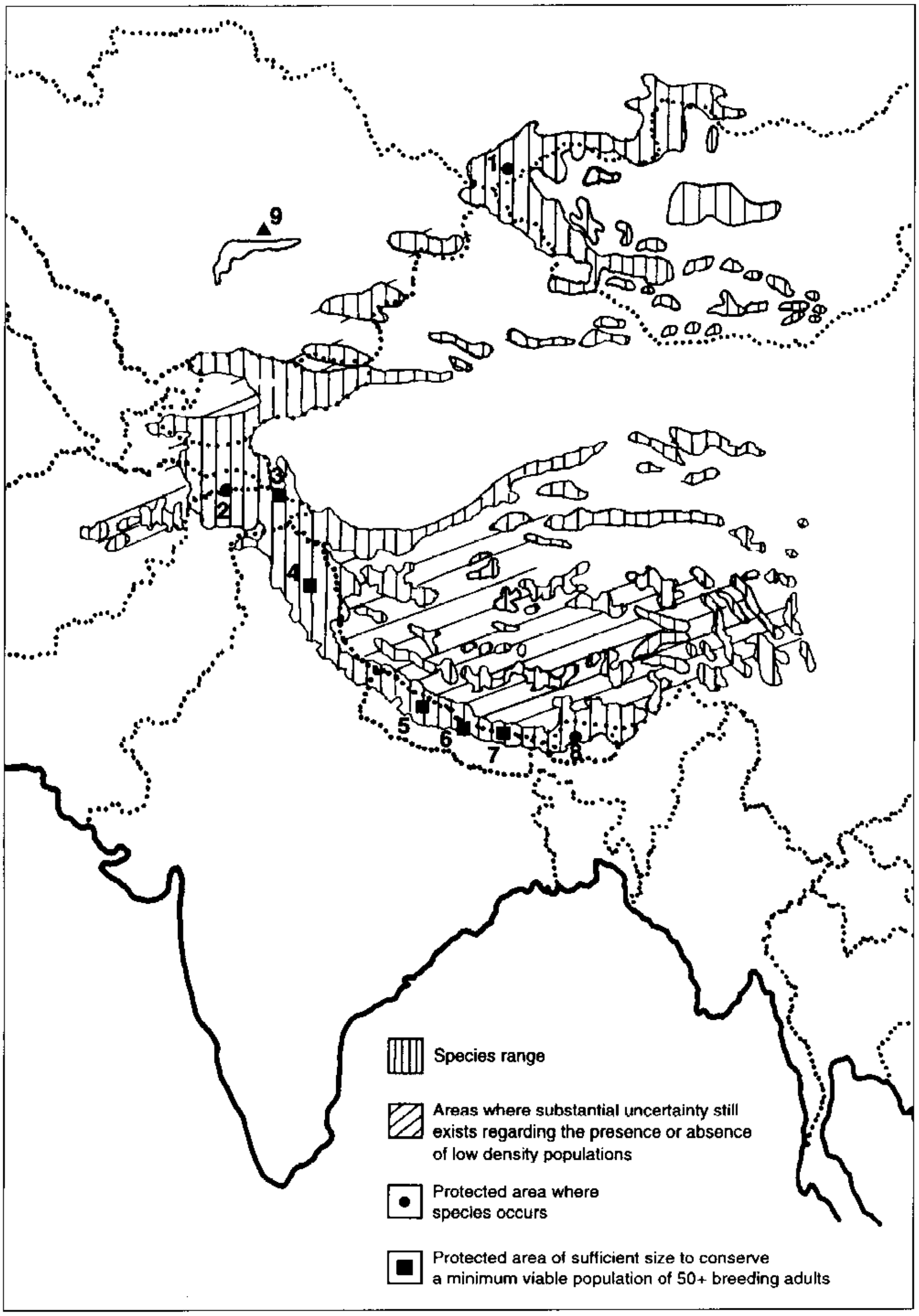

Figure 1. Distribution of the snow leopard (*U. uncia*) after Fox (1994).
1. Sayano-Shushenskiy I* (Russia); 2. Pamir-i-Buzurg IV (Afghanistan); 4. Khunjerab II (Pakistan); 3. Taxkorgan IV (Xinjiang, China) + Khunjerab II (Pakistan); 4. Hemis II (India); 5. Shey-Phoksundo II complex; 6. Annapurna Conservation Area (Nepal); 7. Qomolongma IV (Tibet, China) + Langtang II + Sagamartha II** (Nepal) complex; 8. Jigme Dorji IV (Bhutan); 9. Adult snow leopard captured in the winter of 1957-1958 on the shore of Lake Balkhash, more than 600 km from the nearest mountain ranges (Heptner and Sludskii 1972).

Table 2
Protected Areas for Snow Leopards by Range State and Size
(International Snow Leopard Trust, May 1993)

	Number of Protected Areas				
Country	**< 500 km²**	**500-1,000 km²**	**1,000-6,000 km²**	**5,000-10,000 km²**	**>10,000 km²**
Afghanistan	1	1	0	0	0
Bhutan	0	0	0	1	0
China	3	0	5	0	4
India	24	8	7	0	0
Kazakhstan	0	3	0	0	0
Kyrgyzstan	4	1	0	0	0
Mongolia	0	1	1?	0	1
Nepal	2	0	6	0	0
Pakistan	18	1	2	0	0
Russia	1	1	0	0	0
Tajikistan	2	0	0	0	0
Uzbekistan	1	3	0	0	0
Total	56	19	21	1	5

Jackson (1992) stresses the importance of establishing more coherent trans-frontier protected area systems, such as in key unprotected habitat along the Mongolia-Kazakhstan-China-Russia border areas.

habitat scattered throughout a vast region surrounding the central Asian deserts and plateaus. Although the snow leopard's range extends over some 2.3 million km² of central Asia, occupied habitat is estimated at only 1.6 million km², most of which is in Tibet and other parts of China (Fox 1994). Through most of their range, snow leopards are associated with steep rocky slopes with arid and semi-arid shrubland, grassland, or steppe vegetation (Fox 1989, Jackson 1992). In the mountains of Russia and parts of the Tian Shan they visit in open coniferous forest, but generally avoid dense forest (Heptner and Sludskij 1972, E. Koshkarev, pers. comm.).

Snow leopards are generally found at elevations between 3,000-4,500 m, although they occasionally go above 5,500 m in the Himalaya, and at the northern limits of their range can be found between 600-1,500 m (Heptner and Sludskii 1972, Fox 1989, Schaller *et al.* 1994). Steep terrain broken by cliffs, ridges, gullies, and rocky outcrops is preferred (Koshkarev 1984, Mallon 1984a, Jackson and Ahlborn 1984, 1988, Chundawat 1990b, Fox *et al.* 1991a), although in Mongolia and on the Tibetan Plateau they can be found in relatively flat country (Mallon 1984b, Schaller *et al.* 1994), especially if ridges offer suitable travel routes, and shrub and rock outcrops provide sufficient cover (Schaller *et al.* 1988a). In general, snow leopards tend to move, bed, and mark along linear topographic features, such as major ridgelines, bluff edges, gullies, and the base or crest of broken cliffs (Jackson and Ahlborn 1988).

Population Status

Global: Category 2(A). Regional (Eurasia): Category 1(A). IUCN: Endangered. Estimates of the total snow leopard population vary from 4,500 to 7,500 individuals (Jackson 1992, Fox 1994). Earlier lower estimates, e.g., 1,500 by Green (1988) and 4,000 by Fox (1989), reflected a lack of information from large areas of snow leopard range. China is home to the largest number of animals (mainly in the Tibetan region), and Kyrgyzstan and Mongolia hold the next largest population. Country estimates are shown in Table 1.

Status surveys for the snow leopard have been relatively extensive, compared to other species, and the International Snow Leopard Trust (ISLT), based in Seattle, Washington (U.S.), maintains a database of field reports and local population estimates. The Trust is developing a protocol for standardizing survey techniques (ISLT in prep.), and has signed agreements to hold training workshops in key range states (R. Jackson *in litt.* 1993). The Trust has organized three seminars in central Asian range states which have successively refined understanding of the snow leopard's status, biology, and distribution (Freeman 1988, Blomqvist 1990, Fox and Du 1994).

Estimates of snow leopard density range from 0.8 animals per 100 km^2 (Koshkarev 1989, Annenkov 1990) to 10/100 km^2 (Jackson and Ahlborn 1989). Other studies have provided density estimates for local populations within the following countries (expressed in terms of individuals per 100 km^2): Nepal—5-7 (Oli 1991); China—0.5-4 (Schaller 1988a,b); India –0.5-6.6 (Fox *et al.* 1991a); Mongolia—4.4 (Bold and Dorzhzunduy 1976) to 5 (Schaller *et al.* 1994); Kazakhstan– 0.8-4.7 (Koshkarev 1989); Russia—0.75-1.5 (Sopin 1977). Many of these estimates are derived from indirect sign indices (scrapes, scats, scent sprays, and claw rakings) along trails.

Only a few radiotelemetry studies documenting home range have been carried out (Chundawat 1990b, Schaller *et al.* 1994, M. Oli, pers. comm.). Home range size of five snow leopards in prime habitat in Nepal's Langu Gorge ranged from 12-39 km^2, with substantial overlap between individuals and sexes (Jackson and Ahlborn 1989). Small core areas (consisting of 14-23% of total home range) were more heavily used and marked. Core areas were not exclusive, and were used by different animals at different times.

Protection Status

CITES Appendix I. National legislation: fully protected over most of its range. Hunting prohibited: Bhutan (only in protected areas, which cover most of snow leopard range in this country), China, India, Kazakhstan, Kyrgyzstan, Nepal, Pakistan, Russia, Tajikistan, Uzbekistan. Hunting regulated: Mongolia (although trophy hunting is no longer permitted). No information: Afghanistan (Fox 1989, Nichols *et al.* 1991, H. Freeman, pers. comm.).

Occurrence in Protected Areas

Protected areas with estimated populations of 50+ breeding adults are marked with a square in Fig. 1 (J. Fox, R. Jackson *in litt.* 1993).

The International Snow Leopard Trust maintains a database of protected areas where snow leopards are a) definitely, b) likely, and c) possibly present. The total number of protected areas currently stands at 101, and could rise to 115-120 when updated for China and Mongolia. More than half of the reserves are less than 500 km^2 in size, and are likely to harbor only a few breeding pairs (R. Jackson *in litt.* 1993). The 47 protected areas where the presence of snow leopards is confirmed add up to 224,284 km^2 (Green 1994), about 12% of the total range of the snow leopard (Fox 1994).

However, according to Green (1994), the protected area network is unlikely to grow much more: while 76 more protected areas have been proposed in the region and await official recognition, they will add less than 25,000 km^2 to the total. Nearly all are in India and will form the framework of a national conservation strategy modelled after Project Tiger (Govt. of India 1988); however, most of these reserves will be less than 500 km^2 in size, reflecting the scarcity of unpopulated land in the country.

Green (1994) reviewed the status of central Asian protected areas known to contain snow leopards. In general, the integrity of these protected areas is poor: 65% are inhabited by people, and 86% provide grazing lands for livestock. Only 49% have management plans, some of which are pending approval while others require updating. Green (1994) emphasizes the need to focus attention on managing snow leopard populations in unprotected lands, noting Jackson and Ahlborn's (1990) estimate that 65% of Nepal's snow leopards live outside the country's protected areas (see Part II Chapter 1 for more discussion of the status of protected area coverage for snow leopard range).

Principal Threats

Large ungulates have been hunted out of many areas of the high central Asian mountains (Schaller 1977, Cai *et al.* 1989b, Fox *et al.* 1991b, Jackson 1992), and large-scale pika and marmot poisoning programs have also been conducted on the Tibetan Plateau (Smith *et al.* 1990, Miller and Jackson 1994; see discussion in the next species account). Livestock depredation tends to be greater in areas where wild sheep and goat populations have been depleted (Miller and Jackson 1994, Schaller *et al.* 1994), although prey availability is not the only factor influencing depredation (Oli 1994, Jackson *et al.* in prep.). See Part II Chapter 2 for detailed discussion.

There is demand for snow leopard bones for use as substitutes for tiger bone from the Chinese medicine trade (Liao and Tan 1988). Traders will pay up to U.S. $190 for a snow leopard skeleton in Tibet (Jackson *et al.* 1994). In northern Nepal, people have been seen to trade snow leopard bones for sheep along the border with Tibet (Jackson 1992). Garments of snow leopard fur were once highly prized in the fashion world, with high quality coats valued at up to U.S. $50,000 (H. Freeman, pers. comm.). Heptner and Sludskii (1972) and Fox (1989) review central Asian and Russian exports of snow leopard skins during the 20th century; world trade was of the order of 1,000 pelts per year in the 1920s. Although no longer in international trade (see Table 1 in Part II Chapter 4), fur coats have been seen for sale in shops in Kathmandu (Barnes 1989), and "novelty" furs have been seen for sale throughout China, including Taiwan (Anon. 1987c, Low 1991, Jackson 1992, Fox 1994), as well as Mongolia (D. Mallon *in litt.* 1994).

Action Planning

Projects 71-75.

Chinese mountain cat, *Felis bieti* Milne-Edwards, 1892

Other Names

Chinese desert cat (English); chat de Biet (French); Graukatze (German); gato de Biet, gato del deserto de China (Spanish); mo mao, huang mo mao, cao shihli (Chinese); shel misigi (Kazakh); qel müshüki (Uygur).

Description and Behavior (Plate 11)

The Chinese mountain cat, endemic to China, is one of the least-known cats. It has a stocky build, with relatively short legs. Its coat is pale grey-fawn in winter, somewhat darker brown in the summer, and marked with indistinct horizontal stripes on the sides and legs. Its ears have slight dark brown tufts. The tail is fairly short (35 cm: Jacobi 1923), about 40% of head-body length; it is banded with 5-6 dark grey bands, and has a black tip. The auditory bullae are moderately large, measuring about 25% of total skull length (Pocock 1951). A wild male and female brought to the Beijing Zoo weighed nine and 6.5 kg, respectively (Tan 1984).

What little is known of this species in the wild is mainly due to the efforts of collectors from the Xining Zoo, who obtained 34 specimens between 1973-1985 (Liao 1988, B. Tan *in litt.* 1991). Chinese mountain cats are predominantly nocturnal, active from dusk to dawn in captivity (B. Tan *in litt.* 1991), and hunting primarily in the early morning and evening in the wild (Liao 1988). They rest and tend their young in burrows, typically situated on south-facing slopes. Males and females live separately, and the burrows inhabited by females tend to be deeper and more secure, with only one entrance (Liao 1988). Scat analysis indicates that rodents are the major prey (90%), primarily mole-rats, white-tailed pine vole, and pikas. Birds, including pheasants, are also caught. Liao (1988) observed mountain cats hunting mole rats by listening for their movements through their subterranean tunnels (3-5 cm below the surface), and digging them out.

Biology

Reproductive season: (C & W) January-March mating season, litters often born in May.

Litter size: 2-4.

Age at independence: 7-8 months (Liao 1988).

Habitat and Distribution

The Chinese mountain cat is known only from the north-eastern edge of the Tibetan Plateau (Fig. 2). It has been collected most frequently from Qinghai province, but also from the mountains of southern Gansu and northern Sichuan. Reports of it occurring further north and east, in

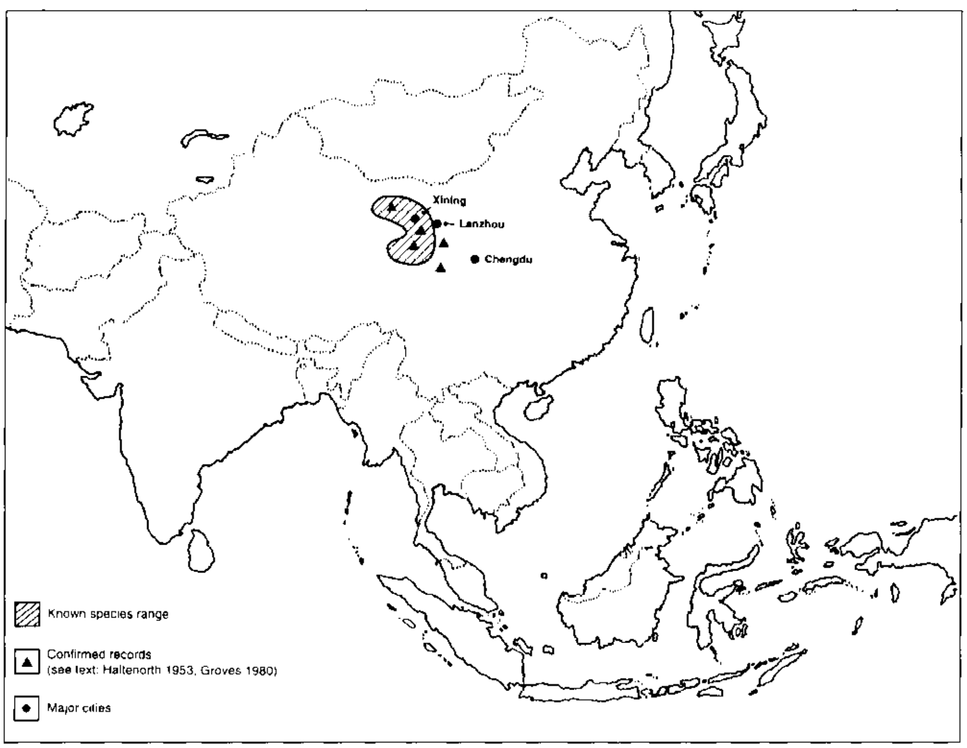

Figure 2. Known distribution of the Chinese mountain cat (*F. bieti*).

flatter, more desert-like terrain (*F.b. chutuchta* and *F.b. vellerosa:* Pocock 1951), probably refer respectively to misidentified specimens of Asiatic wildcat and domestic cat (Haltenorth 1953, Groves 1980). It may occur along the northern edge of the Tibetan Plateau, in the desert mountains of Xinjiang (Pamir and Kunlun Mountains: Wang and Wang 1986, X. Gao *in litt.* 1993), but such reports have yet to be confirmed (Achuff and Petocz 1988, A. Abdukadir *in litt.* 1993). The southernmost records near Chengdu (Fig. 2) are from the same sort of area where the giant panda is found, an entirely different habitat type consisting of montane bamboo forest. Allen (1938) notes that these specimens, obtained in the late 1800s in the fur markets of Tatsienlu and Sungpan (Sichuan province), were probably not locally obtained, and speculates that they came from "the borderlands of the extreme western edge of China or even from Tibet."

According to Liao (1988), the Chinese mountain cat is found throughout the Datong and Daban mountains around Xining (where eight skins were collected by Buchner in 1893: Groves 1980), at elevations ranging from 2,800-4,100 m. It chiefly inhabits alpine meadows and scrub. It has also been found in hilly loess steppe and coniferous forest edge. Despite its traditional name (Chinese desert cat), it appears not to be a desert cat at all (Groves 1980), although it may occur there marginally (Liao 1988; A. Abdukadir, X. Gao *in litt.* 1993). Chinese specialists meeting in Beijing in 1992 concurred with Groves' (1980) suggestion that it be described as the "mountain cat" (Jackson 1992b).

Population Status

Global: Category 2. Regional (Asia): Category 1. IUCN: Insufficiently Known. There is no information on status or abundance, and no records of occurrence in protected areas. The Chinese mountain cat appears to have a very limited distribution, but may have a much wider range further west on the edge of the Tibetan plateau. It is interesting that Liao (1988) collected most of his animals from mountainous areas very close to Xining and Lanzhou, the capitals of Qinghai and Gansu provinces.

Protection Status

CITES Appendix II. National legislation: fully protected in China. The species is currently classified as a Category II species under Chinese law, and the 1992 meeting of the Cat Specialist Group in Beijing recommended upgrading to Category I, which requires permission of national, rather than provincial, authorities to hunt or trade.

Principal Threats

Large-scale poisoning campaigns have been conducted since 1958 in China in an attempt to control "pest" populations of pikas, which are viewed as competitors of domestic livestock for graze. Zinc phosphide was one of the main chemicals used (G. Schaller *in litt.* 1992), from the onset of control efforts up until 1978, when its use was discontinued because it was discovered that it also killed carnivores that preyed on pikas. Control programs using poisonous chemicals continue throughout much of the Chinese mountain cat's range (Smith *et al.* 1990), and have eradicated pikas from large areas (A. Smith, pers. comm. 1994). However, research has indicated that pikas reach their greatest densities and cause greatest damage when rangeland has already been significantly degraded by domestic stock (Shi 1983, Zhong *et al.* 1985), suggesting that the authorities could most effectively control pika populations by focusing their efforts on measures to prevent overgrazing. Healthy predator populations should serve to limit pika numbers, as pikas are an important food source for a variety of carnivores and birds of prey (Smith *et al.* 1990).

No other threats are known. G. Schaller (*in litt.* 1992) noted that pelts of this species can be commonly found in markets in Xining, and Low (1991) saw two mounted specimens for sale in southern China. It would seem unlikely, however, that hunting efforts specifically target the mountain cat.

Action Planning

Projects 76 and 80.

Manul, *Otocolobus manul* (Pallas, 1776)

Other Names

Pallas's cat (English); chat manul (French); Manul (German); gato manul, gato de Pallas (Spanish); yalam (Bashkir); malem (Bukharian); tu sun, wulun, manao, yang shihli (Chinese); psk kuhey (Dari: Afghanistan); malin (Kazakhstan, Mongolia); kazail malin (Kazakh, Ustyurt region); madail (Kyrgyzstan); ribilik (Ladakhi: India); manul (Russia); sabanchi (Smirech'e and Kazakh); mana (Soyot); molun (Uygur); malin, dala mushugi (Uzbek).

Description and Behavior (Plate 12)

Peter Pallas, who first described the manul, erroneously suggested that it was the ancestor of the long-haired Persian breeds of domestic cat, because of its long fur, stocky build and flattened face. The hair on its underparts and tail is nearly twice as long as on the top and sides (Gao *et al.* 1987). Like the snow leopard, this presumably helps keep the animal warm when it hunts on snow, cold rock, or frozen ground (A. Abdukadir *in litt.* 1993). The background color of its fur varies from grey in the north of its range to fox-red in some parts of the south (Ognev 1935, Pocock 1951, Roberts 1977), although greyish animals are also found in the south (Heptner and Sludskii 1972). The hairs have white tips, producing a silvery, frosted appearance in all but the reddest specimens. The body is compact, with short legs marked with indistinct black bands, and a thick, short, black-tipped tail (about 45% of head-body length). Weight ranges from 2-4.5 kg (Pocock 1939a, Heptner and Sludskii 1972, Gao *et al.* 1987). The forehead is patterned with small black spots. Its ears are small and rounded and set low on the sides of the head. The auditory bullae are enlarged, similar to those of the sand cat (Pocock 1951, Heptner and Sludskii 1972). The barking call of the manul is similar also to that of the sand cat (Heptner and Sludskii 1972) and, likewise, the low profile of its head is an adaptation to hunting in open country where there is little cover (Pocock 1907b).

In the Lake Baikal region, analysis of 502 scats found pikas to form the major part of the manul's prey (89%), with small rodents also frequently taken (44%). Other prey included susliks (3%), birds (2%), and insectivores (1%) (Fetisov 1937). Bannikov (1954) reported that one cat's stomach from Mongolia contained the remains of 16 voles; another contained two pikas, one vole, and a hamster. Pikas and small rodents were also reported to be the major prey in Ladakh (Stockley 1936) and China (Feng *et al.* 1986, Gao *et al.* 1987, Anon. 1987a, Cai *et al.* 1989a). One cat in Baluchistan, Pakistan, was found feeding on chukor partridge (Roberts 1977). Manuls are generally crepuscular, being most frequently encountered at dusk or in early morning, but are occasionally seen at mid-day (Heptner and Sludskii 1972). They den in small caves and rock crevices, and may take refuge in the burrows of other animals such as marmots, foxes, and badgers (Bannikov 1954, Y. Ma, pers. comm. 1992). Heptner and Sludskii (1972) reported that tame manuls hunting for rodents caught not only animals running on the surface, but also successfully ambushed them by hiding near exits of burrows, using their paws to fish out the inhabitants when the holes were shallow enough.

Biology

Reproductive season: (C & W) Most litters born April-May (Fetisov 1937, Bannikov 1954, B. Tan *in litt.* 1991).

Estrus: (C) 26-42 hours (n=1: Schauenberg 1978) - 5 days (n=2: Mellen 1989).

Estrus cycle: (C) 46 days (n=1: Mellen 1989).

Gestation: (C) 66-67 days (n=2: Mellen 1989); 74-75 days (n=1: Schauenberg 1978).

Litter size: (C,W) 3.57 ± 0.53 (n=7: Mellen 1989); range up to six or eight (Heptner and Sludskii 1972).

Age at sexual maturity: (C) females - one year (Mellen 1989).

Longevity: (C) up to 11.5 years (Jones 1977).

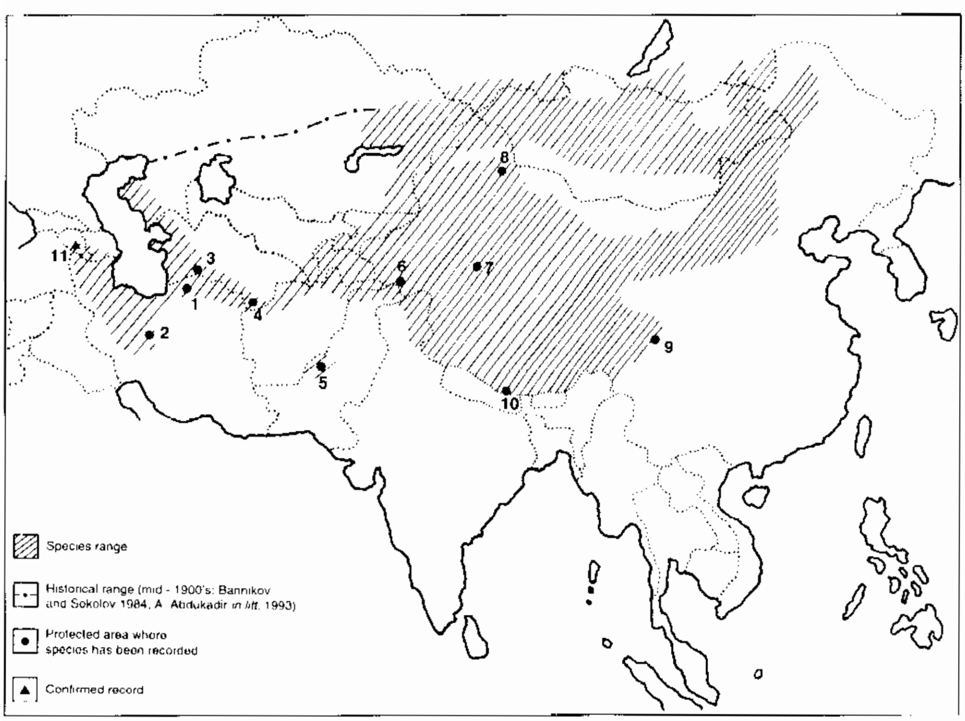

Figure 3. Distribution of the manul (*O. manul*).
1. Khoshyeylag I; 2. Moteh V (Iran); 3. Syunt-Khasardag + Kopetdag I complex; 4. Badkhyz I (Turkmenistan); 5. Ziarat Juniper IV (Pakistan); 6. Taxkorgan IV; 7. Arjin Mts. IV; 8. Boghdad Mts. IX*; 9. Wolong IV*; 10. Qomolongma IV (China); 11. Specimen collected from the Sarai-Bulag Mountains, near Yerevan, Armenia (Ognev 1935).

Habitat and Distribution

The manul is adapted to cold arid environments and has a wide distribution through central Asia (Fig. 3), but is relatively specialized in its habitat requirements. It is found in stony alpine desert and grassland habitats, but is generally absent from lowland sandy desert basins (Bannikov 1954; E. Matjuschkin *in litt.* 1993), although it may penetrate these areas along river courses (Ognev 1935): i.e., it has been recorded from the Dzungarian Basin and Takla Makan Desert in Xinjiang, China (A. Abdukadir *in litt.* 1993). The small southern populations in Baluchistan, isolated from the main population, occur in montane juniper steppe (Roberts 1977). The manul's range ends in the north where the steppes meet coniferous taiga forest (Bannikov 1954). It has been found at altitudes up to 4,800 m (Feng *et al.* 1986), but it does not occur at such high elevations as the snow leopard, and is more strongly associated with flat, rolling steppe and south-facing slopes where deep snow cover does not accumulate. Exposed rock outcrops or expanses of talus are a strong characteristic of its habitat (Heptner and Sludskii 1972). Manuls have been collected from the fringes of cultivated areas in China's Qinghai province (Cai *et al.* 1989a).

Population Status

Global: Category 4. Regional (Asia): Category 2. IUCN: Insufficiently Known. The manul has been described as most abundant on the cold grasslands of Mongolia and Inner Mongolia (Mallon 1985, Feng *et al.* 1986, Y. Ma, pers. comm. 1992). On the Tibetan Plateau, it occurs widely but is nowhere common (G. Schaller *in litt.* 1993), as most of the region lies above 4,500 m in elevation. Elsewhere, the species is considered vulnerable to rare and uncommon: Afghanistan (Habibi 1977), Lakdakh, India (Mallon 1991), and Pakistan, especially the small, isolated populations found in Baluchistan (Roberts 1977). In particular, the manul has disappeared in recent years from much of the Caspian region (Bannikov and Sokolov 1984, Belousova 1993). Y. Ma (pers. comm. 1992) reports that it has been eliminated from the easternmost parts of its range in China due to hunting.

Protection Status

CITES Appendix II. National legislation: lacking information. Hunting prohibited: Armenia, Azerbaijan, China, India, Iran, Kazakhstan, Kyrgyzstan, Mongolia, Pakistan, Russia, Turkmenistan, Uzbekistan. No information: Afghanistan, Georgia, Tajikistan (Nichols *et al.* 1991, Belousova 1993, IUCN Envl. Law Ctr. *in litt.* 1994).

Principal Threats

Although there has been little recent international trade, the manul has long been hunted for its fur in relatively large numbers. Western China's annual harvest (excluding Inner Mongolia and Manchuria) in the early 1950s was of the order of 10,000 (Tan 1984). Annual take in Mongolia in the early 1900s was reportedly as high as 50,000 skins (Heptner and Sludskii 1972). Between 1958-68, harvests averaged 6,500 animals (Mallon 1985). In the mid-1970s, annual harvest in Afghanistan was estimated to be 7,000 (Rodenburg 1977). Harvests in the former Soviet Union declined in the 1970s, suggesting a decrease in abundance (Bannikov and Sokolov 1984). Harvests also declined in China in the 1970s-1980s prior to extension of legal protection to the species (Tan 1984). Mongolia was the primary exporter of manul pelts in the 1980s, with 9,185 exported in 1987, but hunting was prohibited in 1988, and exports have essentially ceased (WCMC unpubl. data).

Poisoning to control pika populations has taken place on a large scale in parts of the Russian Federation (southwest Transbaikalia, Tuvinskaya, Altai Mountains), where they are considered to be vectors for plague, and parts of China (Qinghai, Gansu, and Inner Mongolia), where they are considered to compete with domestic stock for graze (Smith *et al.* 1990).

Action Planning

Projects 77-80.

Asiatic wildcat, *Felis silvestris, ornata* group (Gray, 1830)

Other Names

Asiatic desert wildcat, Asiatic steppe wildcat, Indian desert cat (English); chat sauvage d'Asie, chat orné (French); Asiatische Wildkatze, Steppenkatze (German); gato montés, gato silvestre (Spanish); ye mao, caoyuan ban mao (Chinese); psk dsty (Dari: Afghanistan); velis cata (Georgian); myallen, sabancha, myshuk dala, jawa misik (Kazakh); matsyl, zhapayi mishik (Kirgiz); jhang meno (Kutch: India); tsookhondoi (Mongolia); Asiaskiya dkikaya stepnaya koshka, dlinahvostaya koshka, pyatnistaya koshka (Russian); yawa müshük (Uygur); choi pshak, sabancha, yobai pshak (Uzbek).

Description and Behavior (Plate 12)

The wildcats of central Asia differ from the European wildcats by having a more greyish-yellow or reddish background color, marked distinctly with small black or red-brown spots. The spots are sometimes fused into stripes, especially in the central Asian regions east of the Tian Shan Mountains (Groves 1980). The Asiatic wildcats tend to be smaller in size, weighing between 3-4 kg (Schaller 1967, Roberts 1977), with females (mean 2.7 kg:

Hemmer 1976) smaller than males. Some authorities consider the Asiatic wildcats and African wildcats to be conspecific (*F. lybica* spp.), and the European wildcat (*F. silvestris*) a separate species (Pocock 1951, Ewer 1973, Leyhausen 1979).

Like the other wildcats, rodents are the preferred prey: jerboas, gerbils, voles, and mice (Ognev 1935, Allayarov 1963, Heptner and Sludskii 1972, Sharma 1979). The diet also includes hares, young ungulates, birds, insects, lizards, and snakes (Ognev 1935, Sapozhenkov 1961b, Allayarov 1963, Lay 1967, Heptner and Sludskii 1972, Roberts 1977, Sharma 1979). Sharma (1979) observed a mother teaching her young to kill by bringing them injured gerbils; she also provisioned them with beetles and eggs of ground birds. Asiatic wildcats rest and den in burrows (Ognev 1935, Allayarov 1963, Heptner and Sludskii 1972, Sharma 1979). They are frequently observed in the daytime (Heptner and Sludskii 1972).

Biology

Reproductive season: (W) Mating season March-April and November-December (Rajasthan, India: Sharma and Sankhala 1984); January-February (central Asia: Kashkarov 1931, Allayarov 1963); year-round (Sind, Pakistan: Roberts 1977).

Gestation: (C) 58-62 days (Hemmer 1976, Roberts 1977).

Litter size: (C) 2.75 (n=16; Mellen 1989); (W) up to 5-6 (Ognev 1935, Sharma 1979).

Age at sexual maturity: (W) 10 months (Roberts 1977), but up to 21-22 months according to testicular development in males (Heptner and Sludskii 1972).

Habitat and Distribution

Asiatic wildcats are most typically associated with scrub desert (Allayarov 1963, Sharma 1979; T. Roberts *in litt.* 1993) (Fig. 4). They do not occur in the steppe grasslands of Mongolia and Inner Mongolia (Zhang 1991; X. Gao, D. Mallon *in litt.* 1993), nor in alpine steppe (T. Roberts *in litt.* 1993). They range up to 2,000-3,000 m in mountain areas with sufficient dense vegetation (Allayarov 1963, Heptner and Sludskii 1972). Wildcats can be found near cultivated areas (Salikhbaev 1950, Sharma 1979) and human settlement (T. Roberts *in litt.* 1993). They usually occur in close proximity to water sources, but are also able to live year-round in waterless desert. Snow depth limits the northern boundaries of their range in winter (Heptner and Sludskii 1972).

The Caucasus is the transitional zone between the European wildcat (*silvestris* group) to the north and west, and the Asiatic wildcat to the south and east. In this region, European wildcats are found in montane forest, and Asiatic wildcats are found in the low-lying desert and

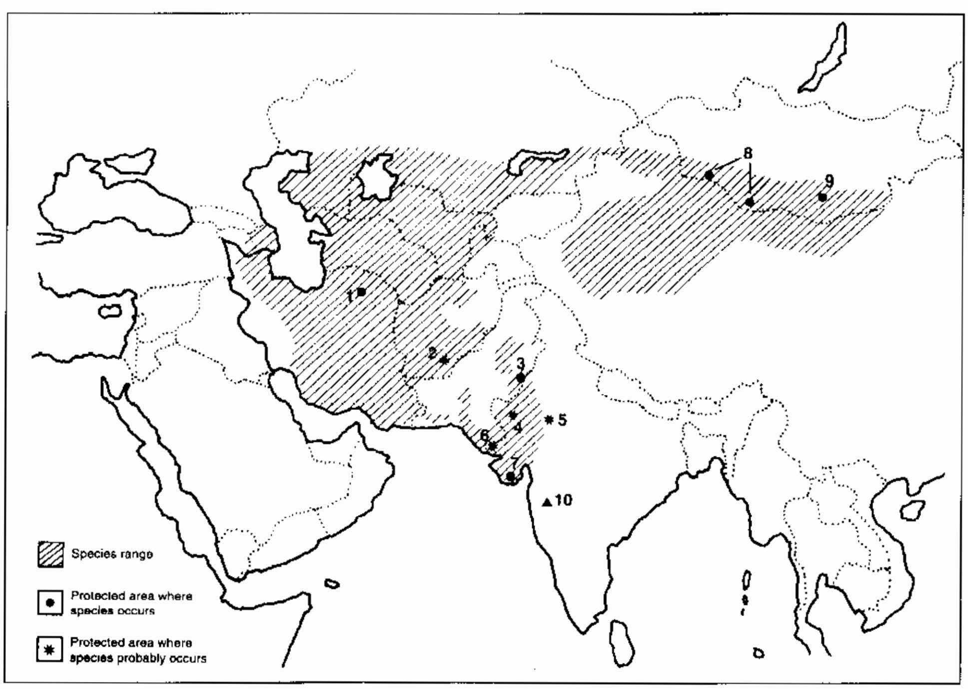

Figure 4. Distribution of the Asiatic wildcat (*F. silvestris, ornata* group).
1. Khoshyeylag I (Iran); 2. Registan Desert Wildlife Mgt. Reserve (proposed: Afghanistan); 3. Lal Suhanra V* (Pakistan); 4. Desert II; 5. National Chambal IV; 6. Naroyan Sarovar IV; 7. Gir II complex (India); 8. Great Gobi II*; 9. Yolyn-am I (Mongolia); 10. Two specimens collected from the Pune area, India (Lamba 1967).

semi-desert areas adjoining the Caspian Sea (Dal 1954, Heptner and Sludskii 1972).

Population Status

Global: Category 5c. Regional (Asia): Category 2. IUCN: not listed. In the central part of its range, Belousova (1993) and E. Matjuschkin (*in litt.* 1993) report that the wildcat is common and populations stable in the lowlands of Kazakhstan. In Azerbaijan, the *ornata-silvestris* transition zone, a pronounced loss of range has been documented (Belousova 1993). In India, the eastern limit of its range, the Wildlife Institute of India (*in litt.* 1992) considers that 90% of the species' habitat in India has been lost. On the other hand, Sharma (1979), who studied the species in western Rajasthan, noted that the introduced mesquite *Prosopis juliflora,* which provides favorable habitat for the wildcat, was spreading extensively in various regions of the Indian desert.

Protection Status

CITES Appendix II. National legislation: fully protected in the east of its range; elsewhere hunted commercially or not protected. Hunting and trade prohibited: India, Pakistan. Hunting and trade regulated: China, Kazakhstan, Kyrgyzstan, Turkmenistan, Tajikistan, Uzbekistan. No legal protection: Georgia, Iran, Mongolia. No information: Armenia, Azerbaijan (Nichols *et al.* 1991, Belousova 1993, A. Bukhnicashvili *in litt.* 1993, IUCN Envl. Law Ctr. *in litt.* 1994).

Principal Threats

In the past, Asiatic wildcats have been trapped in large numbers in several areas: e.g., 12,800 in Kazahkstan (1928-9: Ognev 1935); 1,350 in the Kyzylkum desert (Allayarov 1963); 1,500 annually in the 1980s in Xinjiang (X.-Y. Gao *in litt.* 1992). In 1979, traders in India declared stocks of 41,845 pelts for an export amnesty (Panwar and Gopal 1984). Habibi (1977) reports widespread hunting of the wildcat for the fur trade in Afghanistan, and that large numbers of pelts were seen for sale in Kabul bazaars. Roberts (1977) equates the cat's rarity in Pakistan with demand from the fur trade. However, at present there is little international trade in Asiatic wildcats (WCMC unpubl. data).

Hybridization with domestic cats has been reported from Pakistan (Roberts 1977 and *in litt.* 1993) and central Asia. Heptner and Sludskii (1972: 491) state that "the female [Asiatic wildcat] mates quite often with a domestic male, and hybrid offspring are frequently found near villages where wild females live." The situation in other parts of its range, including India, is probably similar. It has been reported that the most common race of the domestic cat occurring in rural areas in India is colored dark grey, with black stripes and spots, similar in appearance to wildcats but less pale (Pocock 1939a, Kotwal 1984).

Roberts (1977) published reports of predation on domestic poultry, but Heptner and Sludskii (1972) claim that feral domestic cats and hybrids attack poultry more often than wildcats.

Action Planning

Projects 10, 15, and 80.

Eurasian lynx, *Lynx lynx* (Linnaeus, 1758)

Other Names

Lynx (French); Luchs (German); lince (Spanish); sinokoi (Ainu: Sakhalin island); lusan (Armenia); meshag, mesh (Azerbaijan); tsogde (Baltistan: Pakistan); shihli (Chinese); ilves (Finland); lynx (French); potskhveri (Georgia); varchakh (Farsi: Iran); lince (Italy); patsalam (Kashmiri); silovsin, suloosun (Kazakh; Kyrgyz, Uzbek); yi (Ladakhi: India); phiauku (Lahul: India); shleleisin (Mongolia); gaupe (Norway); rys (Russian: Czech Republic, Slovakia, Romania, Russia, Slovenia); lodjur (Sweden); vasak (Turkey); su laisun (Uygur).

Description and Behavior (Plate 11)

The Eurasian lynx is the largest of the lynxes. Adult males weigh on average 21.6 kg (n=103), while females are slightly smaller at 18.1 kg (n=93). The lynxes of eastern Siberia consistently reach the greatest size (Breitenmoser and Breitenmoser-Würsten in prep.). The Eurasian lynx has relatively long legs, and large feet which provide a "snowshoe effect," allowing for more efficient travel through deep snow. In winter, the fur grows very densely on the bottom of the feet (Formozov 1946). The coat is greyish, with tint varying from rusty to yellowish. A bright reddish tint, with profuse spotting, is seen most frequently in the southwestern part of the lynx's range (southern Europe, Asia Minor and the Caucasus: Heptner and Sludskii 1972).

There are three main coat patterns: predominantly spotted, predominantly striped, and unpatterned. While the spotted-striped types, controlled by the "Tabby" gene, predominate in present reintroduced European lynx populations (originating mainly from the Carpathian mountains further east), Ragni *et al.* (1993) show through examination of 26 pelts of the original, now extinct, populations of the European Alps that these animals were chiefly unpatterned, and were, moreover, smaller in size.

Eurasian lynx have long, prominent black ear tufts, and short black-tipped tails. Lynx activity peaks in the evening and morning hours, with resting mainly around mid-day and midnight (Bernhart 1990).

Although the Eurasian lynx is often classified with the three other lynxes as a predator of lagomorphs (e.g., Gittleman 1985), this is a major misconception (Breitenmoser and Breitenmoser-Würsten in prep.). Small ungulates, particularly roe deer, chamois, and musk deer, are the main prey, and lynx will generally only take small prey when ungulates are scarce (Vasiliu and Decei 1964, Danilov *et al.* 1979, Birkeland and Myrberget 1980, Heptner and Sludskij 1980, Jonsson 1980, Somerlatte *et al.* 1980, Pulliainen 1981, Malafeev and Kryazhimsky 1984, Breitenmoser and Haller 1987, Herrenschmidt and Leger 1987, Dunker 1988, Hucht-Ciorga 1988, Cop 1992, Ragni *et al.* 1992, Zheltuchin 1992). When young blue sheep are not available (A. Abkukadir, pers. comm. 1992), lynx in China have been reported to prey on pikas, large rodents, and hares (Feng *et al.* 1986). Pulliainen *et al.* (1988) point out that, in Finland, lynx tend to be in better condition in the southwest—where there is an introduced population of white-tailed deer from North America—than in the remainder of the country, where roe deer are very rare and hares are the main available prey. Similarly, Zheltuchin (1992) states that lynx are found at lower densities in the northern parts of Siberia where there are hares but no ungulates; in these regions, arctic hares and lynx

Figure 5. Distribution of the Eurasian lynx (*L. lynx*). 1. Bialowieza II# (Poland) + Belovezhskaya Pushcha IV (Byelorus) complex; 2. Munzur II (Turkey); 3. Borzhom I (Georgia, possibly now extirpated: Z. Gurielidze and A. Bukhnicashvili *in litt.* 1993); 4. Lisar V; 5. Alborz-e-Markazi V complex (Iran); .6 Pamir-i-Buzurg IV; 7. Ajar Valley IV (Afghanistan); 8. Khunjerab II (Pakistan); 9. Hemis II (India); 10. Taxkorgan IV; 11. Qomolongma IV; 12 Arjin Mts. IV complex; 13. Wolong IV*; 14. Boghdad Mts. IX*; 15. Hanas IV; 16 Changbai Mts. IV* (China); 17. Great Gobi II* (Mongolia); 18. Pechoro-Ilych I; 19. Stolby I (Russia).

fluctuate cyclically (Heptner and Sludskii 1972), similarly to fluctuations described for the Canada lynx (see Species Account).

In some parts of their range, lynx prey mainly on large ungulate species (mostly females or young), including red deer (Hell 1973, Gossow and Honsig-Erlenburg 1986, Jedrzejewski *et al.* 1993), reindeer (Haglund 1966, Bjärvall 1992), and argali (Matjuschkin 1978). Lynx are capable of killing prey 3-4 times their own size (Gossow and Honsig-Erlenburg 1986, Haller 1992).

While all the lynx species are similar in appearance, the Eurasian lynx bears the closest morphological resemblance to the Canada lynx (Kurtén and Rausch 1959), and the two are very often treated as conspecific. However, Breitenmoser and Breitenmoser-Würsten (in prep.) argue convincingly that the two are ecologically separate species. Specialization for different prey has led to a divergence in life history and social and spatial organization. Unlike the Canada lynx, the Eurasian lynx has a "phenotype set" typical of a large felid (Sunquist and Sunquist 1989): it is large, long-lived, kills prey at least half its own body weight, forages over wide areas, and generally exists at low densities. Only in some parts of its range, chiefly the northern boundary, is there ecological similarity between the Eurasian and Canada lynxes in their predation on cyclically fluctuating hare populations.

Biology

Reproductive season: (W) mating season February-April, births May-June (Europe, Russia: Ognev 1935, Dal 1954, Kaczensky 1991, Kvam 1991).

Gestation: (C) average 69 days (Hemmer 1976).

Litter size: (W) 2.5 ± 0.5 (Norway, n=8: Kvam 1991); 1.82 ± 0.6 (Switzerland, n=14: U. Breitenmoser *in litt.* 1993); (C) 2.1 ± 0.9; range 1-4 (n=141: Kaczensky 1991).

Interbirth interval: (W) generally one year, but with occasional breaks, e.g., three years with litters, one without (Switzerland: U. Breitenmoser *in litt.* 1993).

Age at independence: (W) 10 months (Switzerland: Breitenmoser *et al.* 1993a).

Age at first reproduction: (W) females 20-24 months (Kvam 1991, U. Breitenmoser *in litt.* 1993); males approximately 30 months (Kvam 1991).

Juvenile mortality: (W) Breitenmoser *et al.* (1993a) found high rates of juvenile mortality for a lynx population living in a densely settled area of Switzerland: 50% pre-dispersal (n=14 kittens); 80% post-dispersal (n=5 sub-adults).

Recruitment rates: (W) 0.69 (Breitenmoser *et al.* 1993a) - 1.25 ± 1.5 (Kvam 1990) juvenile lynx per female per year.

Age at last reproduction: (W) females 14 years (n=1); males 16-17 years (n=1: U. Breitenmoser *in litt.* 1993).

Longevity: (W) up to 17 years (Kvam 1990, U. Breitenmoser *in litt.* 1993); (C) up to 24 years (Green 1991).

Habitat and Distribution

Throughout Europe and Siberia, lynx are associated primarily with forested areas which have good ungulate populations (Haglund 1966, Novkov and Hanzl 1968, Matjuschkin 1978, Malafeev and Kryazhimskiy 1984, Haller and Breitenmoser 1986, Breitenmoser and Haller 1987). In central Asia, lynx occur in more open, thinly wooded areas (Heptner and Sludskii 1972, Matjushkin 1978, Tan 1984). Lynx are probably found throughout the northern slopes of the Himalayas, and have been reported both from thick scrub woodland (Chundawat 1990a) and from barren, rocky areas above the treeline (Roberts 1977). On the better-forested southern Himalayan slopes, the only record is a sighting in alpine tundra (4,500 m) from the Dhaulagiri region of Nepal (Fox 1985, D. Mallon *in litt.* 1991). Lynx occur locally over the entire Tibetan plateau, and are found throughout the rocky hills and mountains of the central Asian desert regions (Bannikov 1954, Stubbe and Chotolchu 1968, Heptner and Sludskii 1972).

The Eurasian lynx has one of the widest ranges of all cat species, with approximately 75% of the range within the borders of Russia (Fig. 5). Lynx have been recorded as far north as 72° N, near the edge of the continental landmass (Zheltuchin 1992).

Population Status

Global: Category 5b. Regional (Asia): Category 3. Regional (Europe): Category 2. IUCN: not listed. The stronghold of the Eurasian lynx is a broad strip of southern Siberian woodland stretching through Russia from the Ural mountains to the Pacific. The Russian population has been estimated to be 36,000-40,000 (Matjuschkin 1978, Zheltuchin 1992), but it is not clear how these figures were derived (U. Breitenmoser, pers. comm.). Heptner and Sludskii (1972) reviewed reports on lynx distribution in detail, and concluded that in Russia a major population increase and range expansion (including the colonization of the entire Kamchatka peninsula) took place in the 1930s-1940s. Lynx re-colonized areas where they had previously been extirpated, mainly due to a sharp decline in commercial hunting during this period of social upheaval.

In China, lynx are found throughout much of the country, concentrated in the montane regions. Given its wide distribution, Tan Bangjie (*in litt.* 1987) and A. Abdukadir (*in litt.* 1993) are relatively optimistic, but emphasize that in many places it has become locally rare. Ma Yiqing (pers. comm. 1992) believes populations are declining in the northeast. G. Schaller (*in litt.* 1993) notes that lynx are the most commonly seen cat pelts in local fur markets in the west.

Little information is available from the remainder of the lynx's wide Asian range. In Ladakh, Mallon's (1991) survey indicates that it is rare in the central region, but Chundawat (1990a) found it locally common in dense thicket scrub in the Nubra river valley. The lynxes of the central Asian deserts and high mountains inhabit ecosystems very different from the cold coniferous forests with which the species is primarily associated. They appear to prey mainly on hares and rodents, rather than ungulates, but their ecology is little known (A. Abdukadir *in litt.* 1993, U. Breitenmoser, pers. comm.). Bannikov (1954) described lynx as common in the desert hills of southwestern Mongolia. Lynx are now quite rare in the Caucasus (Z. Gurielidze and A. Bukhnicashvili *in litt.* 1993). Animals from this region, with their small size, reddish coat, and heavy spotting, are sometimes recognized as the subspecies *L.l. dinniki*, and were once considered conspecific with the spotted Iberian lynx, *L. pardinus* (Heptner and Sludskii 1972).

The most comprehensive data on species status is from the European sub-region (Breitenmoser and Breitenmoser-Würsten 1990, Anon. 1992b), where lynx are thinly distributed and isolated into discrete sub-populations (Fig. 6). The species was actually eradicated from most of the sub-region within the past 150 years (Kratochvil 1968), surviving only in the north and the east. In these regions, numbers fell in the early 1900s, but recovered concurrently with increases in small ungulate populations (Breitenmoser and Breitenmoser-Würsten 1990). Lynx have since been reintroduced in several parts of western Europe, the most extensive effort for any felid species (see Part II Chapter 6).

In northern Europe (Finland, Norway, Sweden, northeastern Poland, and the European region of the former U.S.S.R.), the population is stable and connected to the larger Siberian population. In central Europe, a relatively large but isolated population is found in the Carpathian Mountains (Slovakia, Poland, Romania, Ukraine). Small

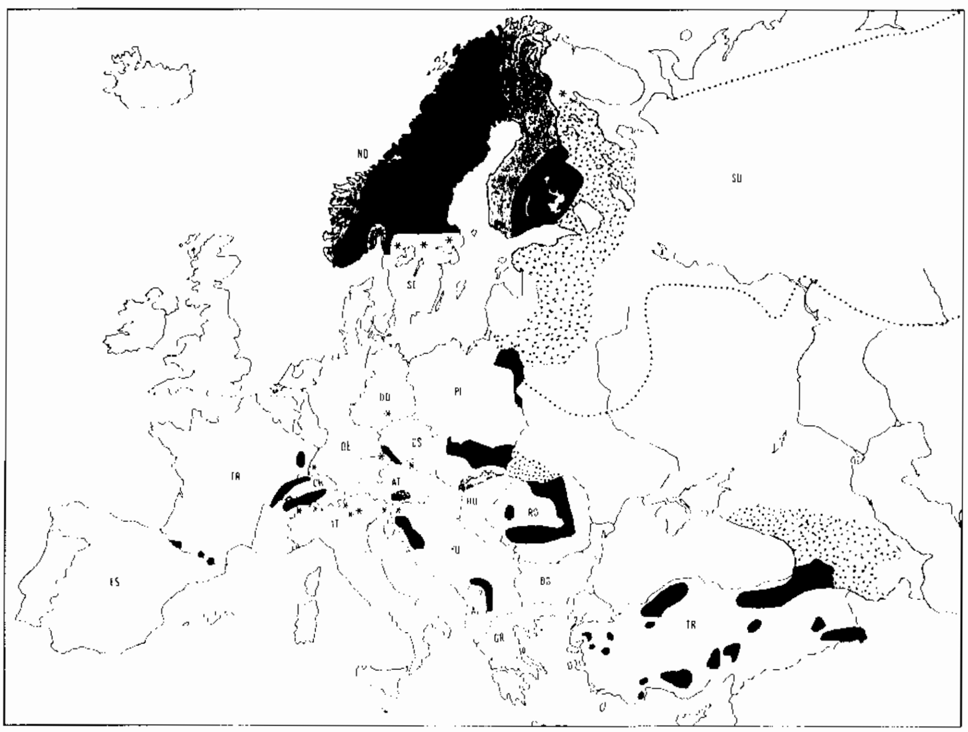

Figure 6. Recent distribution of *Lynx lynx* in Europe (Breitenmoser and Breitenmoser-Würsten 1990). Dark shading: occupied area. Light shading: occasionally occupied area, or area with low population density according to survey respondents. Stippling: lynx range according to the literature. Dotted line: northern and southern boundaries of lynx range in the former U.S.S.R. (Matjuschkin 1978); see Figure 5. Asterisk (*): isolated observations. (AL = Albania, AT = Austria, BG = Bulgaria, CH = Switzerland, ČS = Czech Republic + Slovakia, DE+DD = Germany, ES = Spain, FR = France, GR = Greece, HU = Hungary, IT = Italy, NO = Norway, PL = Poland, RO = Romania, SE = Sweden, SF = Finland, SU = former U.S.S.R., TR = Turkey, YU = former Yugoslavia.

populations are found in the French Pyrenees and Vosges mountains; the Jura Mountains (France, Switzerland); the Alps (Austria, France, Italy, Switzerland); the Balkans (Albania, Croatia and Slovenia); and the Bohemian forest (Czech Republic) (Breitenmoser 1991).

The most thorough estimates of resident adult density (per 100 km^2), derived from radiotelemetry studies, are available from Switzerland: 0.94 (Jura Mountains: Breitenmoser *et al.* 1993a); 1.2 (northern Alps: Haller and Breitenmoser 1986); 1.43 (central Alps: Haller 1992). Based on snow tracking, Hjelm (1991) estimated 0.34-0.74 individuals/100 km^2 in Sweden. Where ungulate prey is abundant, density estimates are high: 10-19 lynx/100 km^2 in the Bialowieza Forest in Poland and Byelorus (Heptner and Sludskii 1972).

Where hares are the major prey, density estimates from Russia are of the order of less than four lynx per 100 km^2 (Zheltuchin 1992).

Excluding outliers, Breitenmoser *et al.* (1993a) reported average home ranges for males of 264 ± 23 km^2, and 168 ± 64 km^2 for females. Within these home ranges, core areas averaged 185 ± 58 km^2 for males, and 72 ± 27 km^2 for females. Females tended to use the central part of their home ranges more intensively (Kaczensky 1991), whereas males regularly visited the periphery of their home ranges (Dötterer 1992). Thus, male core areas averaged 70% of their home ranges and showed some overlap, while those of females were exclusive, and averaged only 44% of their home ranges. With the exception of the overlap zones, one male and one female shared the same area. On average, 86% of a female's home range was covered by a male's home range. Studies from Sweden (Haglund 1966) and Russia (Matjuschkin 1978, Zheltuchin 1984) have also concluded that males generally share their ranges with just one female and her kittens. However, males seem to avoid female core areas, and thus appear to control a zone around females and their kittens, avoiding competition for prey and excluding other male competitors (Breitenmoser *et al.* 1993a).

Protection Status

CITES Appendix II. Hunting prohibited: Albania, Austria, Bulgaria, Czech Republic, France, Georgia, Germany, Greece, Hungary, India, Iran, Kazakhstan, Kyrgyzstan, Nepal, Pakistan, Switzerland, Tajikistan, Turkmenistan, Uzbekistan. Hunting regulated: China, Finland, Slovakia, Mongolia, Norway, Poland, Romania, Sweden, Russia, Turkey. Hunting prohibited in protected areas only: Bhutan, Myanmar. No information: Afghanistan, Armenia, Azerbaijan, Belarus, Estonia, Iraq, Italy, North Korea, Latvia, Lichtenstein, Lithuania, Slovenia, Syria (Breitenmoser and Breitenmoser-Würsten 1990, Nichols *et al.* 1991, Anon. 1992b; A. Bukhnicashvili, E. Mukhina *in litt.* 1993, IUCN Envl. Law Ctr. *in litt.* 1994).

Principal Threats

Lynx are vulnerable to destruction of their ungulate prey base. Under harsh winter conditions, they may not be able to subsist successfully on smaller prey (Pulliainen 1992). Large ungulate prey are favored in the winter because of their vulnerability in deep snow. For example, Scandinavian lynxes have been reported to switch from predation on small game in autumn to large game in winter (Haglund 1966, Birkeland and Myrberget 1980). Hunting pressure may also play a role in lynx population declines (Hell 1992).

Zheltuchin (1992) reported that clear-cutting can have a negative effect on lynx abundance. In the Tver region, lynx were stable and resident when the level of deforestation was approximately 25%. When 80% of an area was clear-cut, the frequency of lynx tracks was about 15 times lower than in areas consisting of 40-50% mature forest cover.

Breitenmoser and Breitenmoser-Würsten (1990) review lynx predation on livestock for European countries, and include information on the different ways it is dealt with by national authorities (see also Part II, Chapter 2). Problems are most severe in western Europe where lynx have been reintroduced. After native wild ungulates re-adapted to the presence of predators, livestock killing increased, but later declined as lynx dispersed and became less concentrated. Overall stock losses are relatively low in these countries, and are compensated either by the government or environmental groups. Switzerland, which invests about U.S. $35 million every year as a subsidy for sheep farming, pays out only about U.S. $7,000 (Anon. 1994a) as annual compensation for lynx kills (rates are agreed upon by stock owners). The problem is thus not really economic, but psychological and political (Breitenmoser and Breitenmoser-Würsten 1990). For 100 years, western European farmers have had the luxury of not having to guard livestock against losses to predators. A prominent French farmer invited to speak at a symposium on the lynx referred to it as "a savage and outdated animal" (Grosjean 1992).

There is no information beyond harvest reports on which to base an assessment of the biological impact of commercial trapping for furs, and thus its significance as a threat is difficult to judge. In Russia, A. Zheltuchin (1992, and in Breitenmoser and Breitenmoser-Würsten 1990) and Matjuschkin (1978) indicated that harvest levels range between 2,000-5,800 annually. The maximum harvest reported (5,800 in 1956) is similar to harvests reported for 1985-1986, which could indicate that the lynx population has remained relatively stable. Annual harvests on the order of 5,000-6,000 have been reported in the Soviet Union as long ago as 1928 (Heptner and Sludskii 1972). Russia exports most of its reported harvest, averaging about 5,000 pelts per year between 1985-1989 (WCMC unpubl. data). There was a surge in exports from China from 1984-1988, with a peak of over 12,000 skins in 1986 (WCMC unpubl. data). This trade was probably in response to high pelt prices prevailing at that time, when Canada lynx populations were at a cyclic low. Given that China lacks the organized trapping infrastructure present in Russia, it is possible that the skins could have been taken originally in Siberia, unaccounted for in the official harvest (U. Breitenmoser *in litt.* 1992).

Both China and Russia announced in 1993 the setting of export quotas for lynx furs: 2,800 per year from Russia, and 1,000 per year from China (Anon. 1993b). Exports of lynx furs from these two countries are currently low, below 1,000 annually.

While lynx reintroduction in Switzerland has been considered a success, Breitenmoser *et al.* (1994) have found that the population has stopped expanding, and is threatened by an imbalanced sex ratio (lack of males). The problems facing the Swiss lynx population are discussed in Part II, Chapters 2, 3, and 6. In general, lynx adapt well to settled and cultivated areas if population levels do not become too low. Lynx have been reported from the outskirts of Moscow, Leningrad, and other large Russian towns (Heptner and Sludskii 1972).

Action Planning

Projects 16, 80, and 84-88.

Europe Sub-region

Iberian lynx, *Lynx pardinus* (Temminck, 1827)

Other Names

Pardel lynx, Spanish lynx (English); lynx d'Espagne (French); Pardelluchs (German); lince iberico (Spanish); lobo cerval (Portugese).

Description and Behavior (Plate 11)

The Iberian lynx looks like a smaller version of the Eurasian lynx, being only about half its size, with adult males weighing an average of 12.8 kg (n=5) and females 9.3 kg (n=4) (Beltrán and Delibes 1993). Iberian lynxes have a distinctly spotted coat, as do Eurasian lynxes of western Europe. However, the two are different species (Werdelin 1990, García-Perea 1992), sympatric in central Europe during the Pleistocene (Kurtén 1968, Kurtén and Grandqvist 1987), with the time of separation estimated to have occurred long before the separation of the Eurasian and Canadian lynxes. Werdelin (1981) considers that both the Eurasian and Iberian lynxes evolved from the first identifiable lynx, *Lynx issiodorensis*—the Iberian in Europe, and the Eurasian lynx (which gave rise to the Canada lynx) in China. Although the ranges of the Eurasian and Iberian lynx never overlapped very much, and have become essentially separate in recent times, the two lynxes may still co-exist in the Pyrenees Mountains between France and Spain (van den Brink 1971, Breitenmoser and Breitenmoser-Würsten 1990).

The ecology of the Iberian lynx is very different from the Eurasian lynx. While the Eurasian lynx is a forest animal which preys on ungulates, the Iberian lynx is found in scrub vegetation and preys almost exclusively on European rabbits. In both ecology and average body weight, the Iberian lynx is very similar to the Canada lynx and bobcat of North America. By weight, 93% of lynx prey during the summer season is made up of rabbits, which suffer particularly at that time from the poxvirus myxomatosis. The proportion of rabbits in the diet decreases slightly in the winter months, when rabbit numbers are at an annual low (Delibes 1980, Beltrán *et al.* 1987). At this time, red deer (fawns), fallow deer, and moufflon (juveniles) are taken (Aymerich 1982, Beltrán *et al.* 1985). In the Coto Doñana wetland area along the southwestern Spanish coast, ducks are a seasonally important food resource from March to May, during their breeding season (Delibes 1980, Beltrán and Delibes 1991). The energy requirements of the Iberian lynx have been estimated at approximately one rabbit per day (Aldama *et al.* 1991).

A radio-telemetry study in the Coto Doñana National Park showed lynxes to be primarily nocturnal, with activity peaking at twilight as the animals moved out of their daytime resting places to hunt. Daily travel distance averaged 7 km, with males generally travelling further than females. Diurnal activity peaks during the winter (Beltrán *et al.* 1987).

Biology

Mating season: (W) January-July, peak January-February.

Birth season: (W) March-April peak.

Gestation: (W) approx. two months.

Litter size: (W) 2-3 (M. Delibes *in litt.* 1993).

Survival to independence: (W) 1-2 kittens per female.

Age at independence: (W) 7-10 months.

Age at dispersal: (W) independent kittens remain in their natal territory until an average of 20 months (range 8-28; n=15).

Age at first reproduction: (W) Females are able to breed in their first winter, but the time of first reproduction depends upon demographic and environmental factors. In a high-density population, such as that in Doñana NP, age at first reproduction depends upon when a female acquires a territory. This normally occurs because of either death or expulsion of a resident. One female did not reproduce until five years of age, and this only occurred when the mother died and left the territory vacant (J. Aldama, P. Ferreras *in litt.* 1993).

Age at last reproduction: (W) 10 years (male and female: M. Delibes *in litt.* 1993).

Longevity: (W) up to 13 years (Ferreras *et al.* 1992).

Habitat and Distribution

The Iberian lynx occurs in Mediterranean woodland and maquis thicket. It favors a mosaic of dense scrub for shelter and open pasture for hunting rabbits (ICONA 1992). Palomares *et al.* (1991) examined habitat preferences of lynx in the Coto Doñana area of southwestern Spain, including the national park and environs. Lynx were generally absent from cropland and exotic tree plantations (eucalyptus and pine), where rabbits were also scarce. In the park, radiotelemetry showed that more than 90% of daytime resting spots used by lynx were located in thick heather scrub (Beltrán *et al.* 1987).

The Iberian lynx has historically been restricted to the Iberian peninsula, where it was widespread (Graells 1897), and southern France (Lavauden 1930). The peninsula was apparently a Pleistocene refuge for the European rabbit, and today the race that occupies this area is only half the size of conspecifics found elsewhere in central Europe (1 vs. 2 kg: Gibb 1990). The Iberian peninsula is the only part of the Palearctic region which supports a relatively high density of lagomorphs, similar to that found in North America, home to two species of lagomorph-eating lynxes: the bobcat and Canada lynx (U. Breitenmoser, pers. comm. 1992).

By the early years of the 20th century, the Iberian lynx had become very rare in northern Spain, although it was still abundant in the center and south (Cabrera 1914). By the 1960s, its range was essentially limited to the southwestern quarter of the peninsula, an area of some 57,000 km^2, where the population probably had a continuous distribution (Rodríguez and Delibes 1990). At present, lynx range in Spain (where 95% of the population is now found) covers only 14,000 km^2, of which about 11,000 km^2 is believed to be breeding range. This represents only about 2% of the country's total area (Rodríguez and

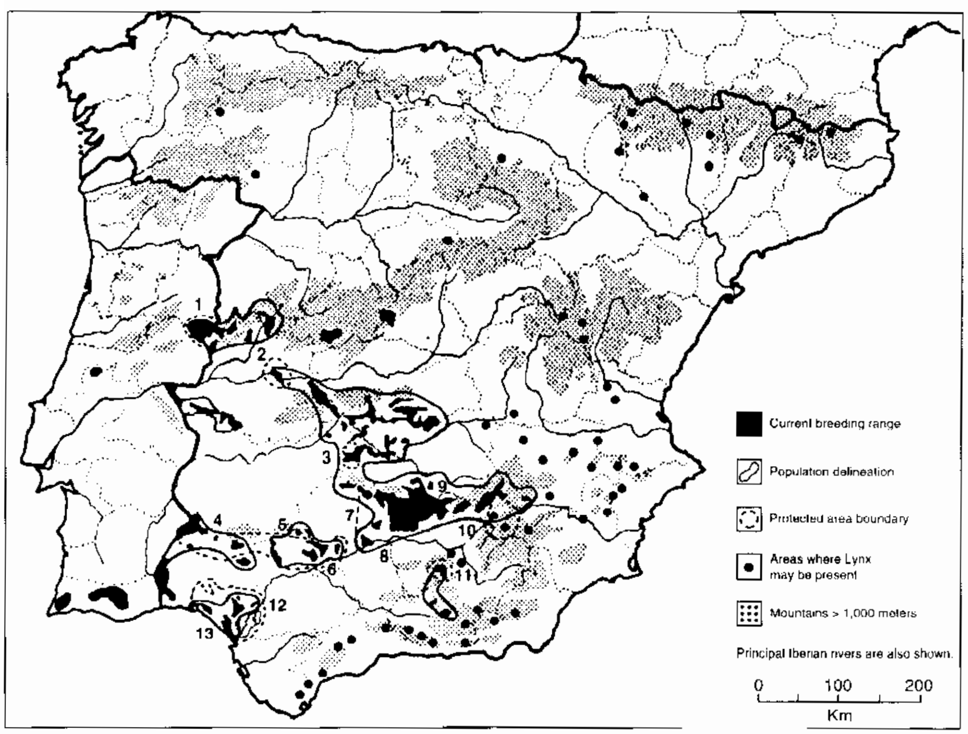

Figure 7. Distribution of the Iberian lynx (*L. pardinus*) after Rodríguez and Delibes (1992).
1. Serra da Malcata IV (Portugal); 2. Monfrague V; 3. Cabañeros V; 4. Sierra de Aracena y Picos de Aroche V; 5. Sierra Norte Natural Park; 6. Sierra de Hornachuelos V; 7. Sierra de Carde:a y Montoro; 8. Sierra de Andujar V; 9. Despeñaperros V; 10. Cazoria, Segura y la Villas Natural Park; 11. Sierra Mgina V; 12. Entorno de Doñana V; 13. Doñana II* (Spain).

Delibes 1992). Distribution in Portugal is less well-known, but has also been substantially reduced since the 1940s. There now appear to be only three breeding sub-populations in that country, occupying a total range of only about 700 km², with the largest now found in the Serra da Malcata Nature Reserve and the Algarve Mountains of the extreme south (Delibes 1979, Palma 1980, ICONA 1992). Lynx distribution is centered on mountain ranges, where land use is mainly in the form of privately owned hunting reserves (ICONA 1992). Lynx are mainly found between 400-900 m elevation, but will range up to 1,600 m (IUCN 19762, Palma 1980).

Population Status

Global: Category 1. Regional (Europe): Category 1. IUCN: Endangered. The Iberian lynx is the only cat species ranked in Category 1. The total number of Iberian lynx, including sub-adults but not kittens, probably does not exceed 1,200, with only about 350 breeding females (ICONA 1992, Rodríguez and Delibes 1992). The lynx population is extremely fragmented. In Spain, a comprehensive survey (Rodríguez and Delibes 1992) documented 48 isolated breeding areas, 32 areas of occasional presence, and 50 other areas where lynx presence is suspected but not confirmed (Fig. 7). Since lynx are known to dis-

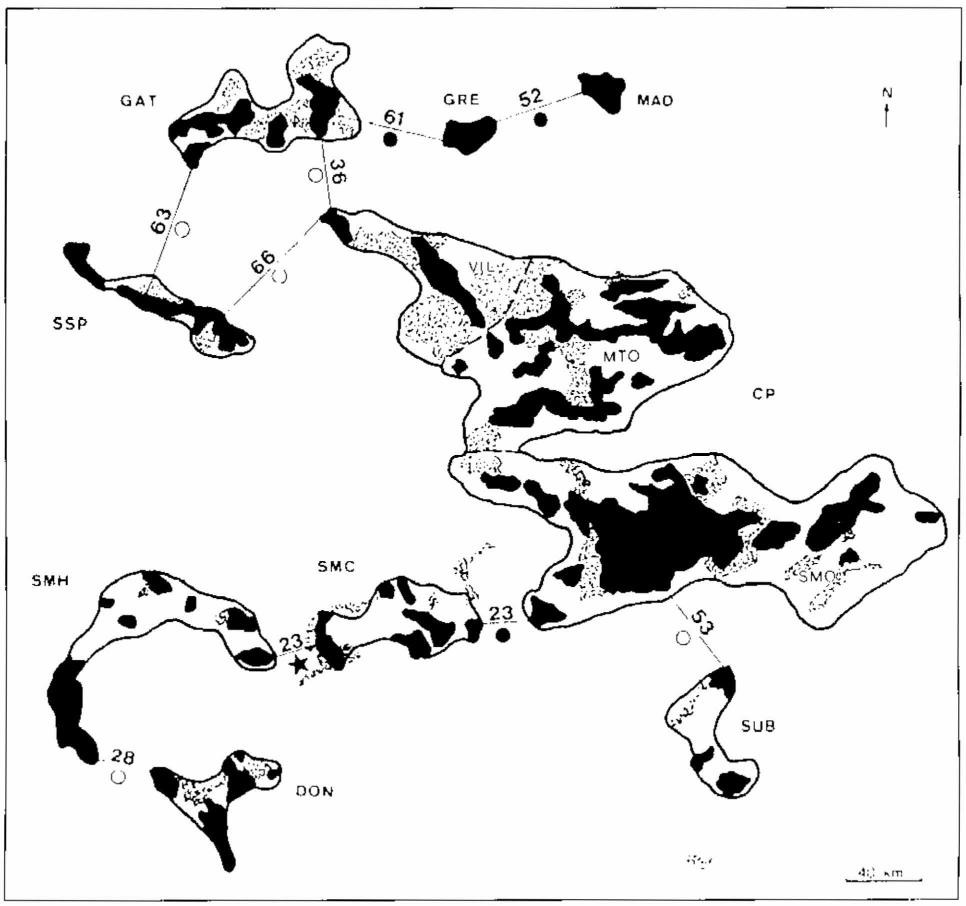

Figure 8. Population structure of the Iberian lynx in Spain (Rodríguez and Delibes 1992). Continous lines surround the nine estimated populations, including breeding (shaded black) and occasional presence areas (stippled). The breeding populations are the same as those shown in Figure 7. Broken lines further delineate three sub-populations (VIL, MTO, SMO). Straight lines represent minimum barrier breadth (km). Symbols indicate the degree of barrier penetrability for lynx: star = high; solid circle = low; open circle = null. GAT = Sierra de Gata. GRE = Sierra de Gredos. MAD = Alto Alberche. SSP = Sierra de San Pedro. CP = Central population (VIL = Villuercas; MTO = Montes de Toledo; SMO = Eastern Sierra Morena). SMH = Western Sierra Morena. SMC = Central Sierra Morena. DON = Doñana; SUB = Sierra Subbéticas.

Table 3
Comparative Importance (%) of Different Causes of Mortality Among Lynxes in Spain (after Rodríguez and Delibes 1990)

Period	Guns	Traps/ Snares	Dogs	Road	Other	N
1958	21.2	67.0	3.5	—	8.2	170
1958-1977	26.0	62.7	2.6	0.1	8.6	689
1978-1988	26.1	44.4	6.7	7.0	15.7	356
Total	25.4	58.0	4.0	2.1	10.6	1,215

perse up to 30 km (Beltrán 1988), the 48 isolated breeding areas and 32 areas of occasional presence are likely to make up nine distinct sub-populations (Fig. 8). These sub-populations are probably genetically isolated, having been separated by intensive agriculture and settlement by an average distance of 45 km. Only two sub-populations occupy areas larger than 2,000 km^2.

Only the central population, consisting of three sub-populations (VIL, MTO & SMO on Fig. 8), is believed to be viable, consisting of some 800 lynx. The remaining sub-populations are estimated at between 13-63 animals (Rodríguez and Delibes 1992). Small population size is a proven threat to the Iberian lynx: it has disappeared from 91% of the areas less than 1,000 km^2 in size which were estimated to have harbored it in 1960 (Rodríguez and Delibes 1990).

Iberian lynxes have been studied using radiotelemetry in the Coto Doñana NP since 1983. In good quality habitat, lynx density (including sub-adults but not kittens) was estimated at 16 individuals per 100 km^2 (Palomares *et al.* 1991). Rodríguez and Delibes (1992) estimated densities across lynx range based on the relationship between reports of lynx presence and actual numbers present, known from the Doñana study area. Densities for the nine genetically isolated sub-populations were estimated at between 4.5-10.1 individuals per 100 km^2. For resident adults in the Doñana, annual home range averages 18 km^2 for males (monthly home range averages 10 km^2) and 10 km^2 for females (monthly home range averages 8 km^2) (M. Delibes *in litt.* 1993). Home ranges are intrasexually exclusive, with complete intersexual overlap (Beltrán *et al.* 1987).

Protection Status

CITES Appendix I. National legislation: fully protected in Spain and Portugal (ICONA 1992). The Spanish government paid a bounty for destruction of lynx up through the 1950s; the lynx was not declared a protected species until 1973 (ICONA 1992). At present, the fine for willful killing of a lynx is very high, approximately U.S. $8,000 (Delibes 1989).

Principal Threats

The decline of the lynx population since the 1960s has been primarily caused by habitat loss and a decline of their main prey species, the European rabbit. The poxvirus, myxomatosis, was introduced from South America in the early 1950s and had a devastating impact on European rabbits, which had no natural immunity. In the early years of the epidemic, rabbits virtually disappeared from many areas. European rabbits are in the process of developing genetic resistance to myxomatosis, which is no longer such an important threat. However, a new disease, viral hemmorrhagic pneumonia, hit the Spanish population in 1988, causing high initial mortality of adult rabbits (Gibb 1990, Villafuerte and Moreno 1991). At the same time, large-scale habitat conversion has taken place in Spain and Portugal, where the pasture-scrub-woodland mosaic preferred by rabbits was replaced by wheat fields and industrial forest plantations. Rabbits are declining even in the montane hunting reserves, probably because small-scale grazing and cultivation have been abandoned in these areas, and the pastureland preferred by rabbits is invaded by thicket (ICONA 1992).

Nevertheless, there are some areas where habitat quality and rabbit density appear sufficient, yet no lynx are found. Particularly in these areas, it seems that humans are directly responsible for an appreciable level of lynx mortality (Delibes 1989). This is true even for the population living in the area receiving the greatest protection, the Doñana NP complex. Most of the deaths recorded there in the last 10 years were human-related, and only 8.3% of the annual mortality rate can be related unequivocally to natural causes (Ferreras *et al.* 1992). Rodríguez and Delibes (1990) compiled records on cause of death for 1,215 lynx killed in Spain over the past 30 years.

Traps and snares, particularly gin traps set for rabbits, have been the principal known cause of death for lynx, although the practice of trapping rabbits is now declining. Road deaths were comparatively unimportant (or seldom reported) before 1978, but are expected to increase as Spain undertakes an ambitious program of road-building in the 1990s (ICONA 1992).

The small, isolated sub-populations of Iberian lynx are theoretically vulnerable to genetic drift, where alleles with low frequency are likely to disappear from the population gene pool. Beltrán and Delibes (1993) found preliminary evidence for this happening in Coto Doñana, where the population of approximately 40-50 lynx has been isolated since the early 1960s. Three pelage patterns were present in the population at that time, but now no animals exhibit the rarer fine-spotted pattern.

The Spanish government is in the process of developing a national conservation strategy for the Iberian lynx, with the goal of enabling the lynx to occupy as large a range as possible on a permanent basis. Management measures will be applied first to the largest population nuclei (the eastern Sierra Morena, the Toledo Mountains, the corridors between these two zones, and certain parts of Extremadura). Measures include completion of detailed surveys of the conditions faced by each lynx sub-population (land use, land ownership, habitat condition, rabbit density); banning rabbit trapping; taking active steps to increase rabbit populations (such as brush clearance); and establishment of a captive breeding program (now underway) (Rodríguez and Delibes 1990, ICONA 1992).

Action Planning

Projects 81-83.

European wildcat, *Felis silvestris, silvestris* group Schreber, 1775

Other Names

Forest wildcat (English); chat forestier, chat sauvage, chat silvestre (French); Wildkatze (German); gato montés, gato silvestre (Spanish); vairi katu, antarayin katu (Armenian); diwa kotka (Bulgarian); ghjattu volpe (Corsican); kodka divoká (Czech); wilde kat (Dutch); tkis cata (Georgian); vadmacska (Hungarian); gatto selvatico (Italian); zbik (Polish); gato bravo (Portugese); pisica-salbatica (Romanian); dikaja koschka (Russian); macka diva (Slovakian); yaban kedisi (Turkey); sauvadge tché (Wallon: Belgium).

Description and Behavior (Plate 12)

The forest wildcats of Europe and western Russia are grey-brown in coat color, with bushy, blunt-ended tails and a well-defined pattern of black stripes. Although they tend to look bigger than African wildcats because of their thick winter fur, an extensive series of weight measurements have shown that they are not: males weigh an average of 5 kg and females 3.5 kg (Condé and Schauenberg 1971). However, the authors did record strong seasonal weight fluctuations ranging up to 2.5 kg, with heaviest male weights recorded from September to the end of February (France).

The fossil record suggests that the European form of the wildcat is the oldest, descended from Martelli's cat (*Felis [silvestris] lunensis*) about 250,000 years ago (Kurtén 1968). Molecular analysis indicates that the African wildcat diverged from the European form only about 20,000 years ago (Randi and Ragni 1991). This is corroborated by the fact that fossil specimens of African wildcats are only known with certainty from the late Pleistocene (Savage 1978). The domestic cat was derived from African wildcats between 4,000-8,000 years ago (Clutton-Brock 1981, Davis 1987, Kitchener 1992). Hybridization is common between European wildcats and domestic cats, and Kitchener (1992) discusses characters (pelage pattern, gut length, skull morphology) that can be used to distinguish reliably pure wildcats from hybrids or domestic tabbies. Many hybrids are more like wildcats in size and morphology than domestic cats: perhaps there is differential survival of hybrid forms in the wild that favors larger cats. Large black cats observed in Scotland ("Kellas cats") and the Caucasus (Satunin 1904, Aliev 1973) are probably introgressive hybrids, with variable proportions of wildcat genes (Kitchener and Easterbee 1992). Black forms (melanistic) have never been recorded in wildcats in Europe, despite being a common coat color mutation in other species of felid (Clark 1976, Robinson 1976, Todd 1977).

As with other wildcats, rodents are the staple of their diet across most of their range (Lindemann 1953, Novikov 1962, Nasilov 1972, Sladek 1973, Condé *et al.* 1972, Ragni 1978, Habijan and Dimitrijevic 1979, Hewson 1983, Stahl 1986, Riols 1988, Fernandes 1993, Ionescu 1993). However, rabbits comprise the major prey where they occur, as in central Spain (Aymerich 1982), and an agricultural area in northeastern Scotland (Corbett 1979). Birds (both passerine and ground-dwelling) are of secondary importance (B. Ragni, P. Stahl *in litt.* 1992). The composition of the diet shows only minor seasonal variations: rabbits or rodents are the major year-round food items. No one species of rodent is preferred (Stahl 1986), but wildcats sometimes prey selectively on rabbits. In northeastern Scotland, for example, juvenile rabbits were taken in the spring birth season, and adults in autumn-winter, when myxomatosis was most virulent in that age class (Corbett 1979). Wildcats will also scavenge food and cache their kills, especially in winter (A. Kitchener *in litt.* 1993).

In western Scotland, Scott *et al.* (1993) found that wildcats were predominantly nocturnal, travelling over 10 km per night to forage on open ground near the coast or around farms and villages, and resting by day in thickets or young forestry plantations. Daytime activity is usually correlated with absence of human disturbance (Stahl 1986, Genovesi and Boitani 1993).

Wildcats can live in very wet, swampy areas (usually among the last types of habitat to be modifed by humans). N.K. Vereshchagin (in Heptner and Sludskii 1972) describes how, when lowland forest is seasonally inundated in the Caucasus mountains, wildcats live in trees for weeks, feeding on rats taking refuge there.

Biology

Reproductive season: (W) mating season in late winter, January-March; most births in May (Smit and Van Wijngaarden 1976, Muntyanu *et al.* 1993).

Estrus: (C) 2-8 days, in presence of males (Condé and Schauenberg 1969).

Gestation: (C) 63-68 days (in Hemmer 1976).

Litter size: (C & W) mean 3.4 (W: n=106; C: n=92; Stahl and Leger 1992); range 1-8 (Green 1991).

Age at independence: (W) 4-5 months (Smit and Wijngaarden 1976, Tomkies 1991); up to 10 months (Muntyanu *et al.* 1993).

Age at sexual maturity: (C) females 10-12 months; males 9-10 months (Condé and Schauenberg 1969, Hemmer 1976, P. Andrews *in litt.* 1993).

Interbirth interval: (C) probably one year. Condé and Schauenberg (1969, 1974) found that males can be sexually active from December-July, but females can only exceptionally breed twice in one year, such as when the first litter is lost (A. Kitchener, B. Ragni *in litt.* 1993).

Mortality: (W) Several studies have reported very high human-caused mortality (e.g., snares, road kills), comprising up to 92% of observed deaths (Corbett 1979, Piechocki 1986, Riols 1988). Human-induced mortality

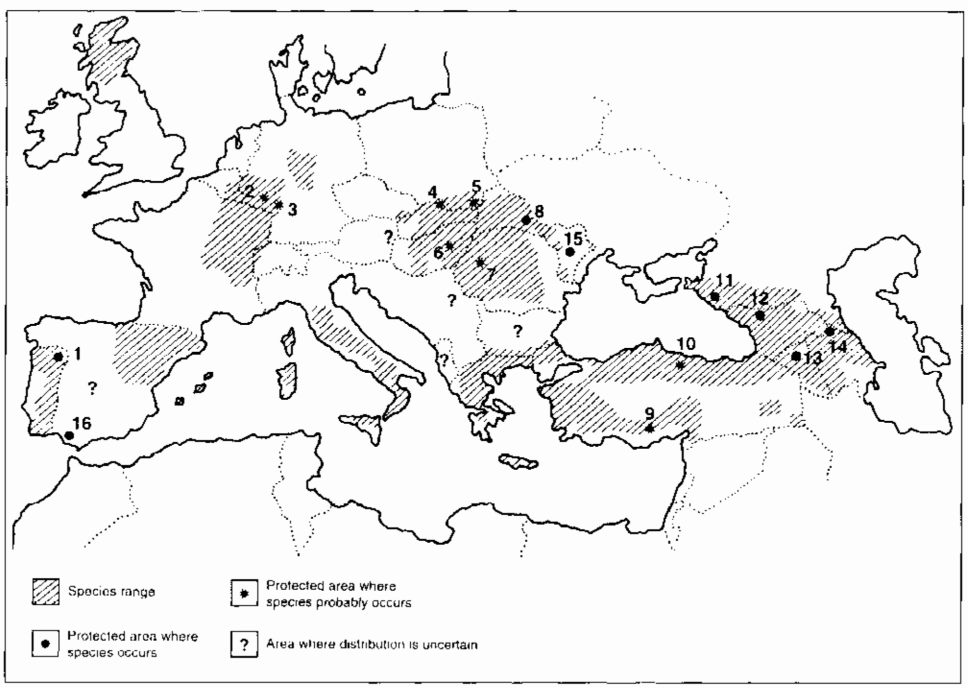

Figure 9. Distribution of the European wildcat (*F. silvestris, silvestris* group) after Stahl and Artois (1991). 1. Montezinho V (Portugal); 2. Nordeifel V; 3. Pfalzerwald V (Germany); 4. Tatransky II; 5. Beskydy V (Poland); 6. Hortobágyi II* (Hungary); 7. Apuseni V (Romania); 8. Karpatskiy II (Ukraine); 9. Karamanbayiri VI; 10. Golardi Sulun VI (Turkey); 11. Kavkaz I* (Russia); 12. Borzhom I (Georgia); 13. Dilijan I (Armenia); 14. Zakatal I (Azerbaijan); 15. Kodry I (Moldavia); 16. Coto Doñana II* complex (Spain).

is probably significant across much of the wildcat's heavily settled range (Stahl and Artois 1991).

Longevity: (C) up to 15 years (Green 1991).

Habitat and Distribution

European wildcats are primarily associated with forest, and are found in highest numbers in broad-leaved or mixed forests (Stahl and Leger 1992). Coniferous forest, however, is probably marginal habitat (Parent 1975, Heptner and Sludskii 1972). Wildcats are also found in Mediterranean *maquis* scrubland (Ragni 1981), riparian forest, marsh boundaries and along sea coasts (Lozan and Korcmar 1965, Heptner and Sludskii 1972, Dimitrijevic and Habijan 1977, Scott *et al.* 1993). They have never been found in the high Alps (Schauenberg 1970); B. Ragni (*in litt.* 1991) further states that forest wildcats are not present in areas where snow cover is greater than 50%, is more than 20 cm deep, and remains for more than 100 days of the year. In general, regions occupied by forest wildcats are characterized by low human density, with cultivation typically taking the form of grazing areas divided into small plots. Rocky areas are a preferred micro-habitat (Heptner and Sludskii 1972). Wildcats are generally absent from areas of intensive cultivation (Easterbee *et al.* 1991, P. Hell *in litt.* 1993).

After the marked decline of the forest wildcat and its eradication from much of Europe between the late 1700s and early 1900s, recolonization has occurred since 1920-1940 in several countries (Belgium, Czech Republic and Slovakia, France, Germany, Switzerland, United Kingdom) (Stahl and Artois 1991 and *in litt.* 1991, 1993). Populations of wildcats occur on Crete, Corsica, Sardinia, and the Balearic Islands, as well as numerous other small Mediterranean islands. Some authorities consider these populations to be discrete subspecies, related most closely to the *lybica* group, and among the most endangered populations in Europe (Arrighi and Salotti 1988, Ragni 1988, B. Ragni *in litt.* 1993). Vigne (1992), on the other hand, considers them to be feral forms of domestic cats introduced centuries before by humans.

Population Status

Global: Category 5c. Regional (Europe): Category 2. IUCN: not listed. Stahl and Artois (1991) carried out a comprehensive status survey, using questionnaires and an extensive literature review, and Fig. 9 is based on their work. The authors have highlighted the importance of establishing data collection networks, and praised the results of such efforts in Scotland (Easterbee *et al.* 1991) and Hungary (Szemethy 1989). In Scotland, the method appeared to be sufficiently sensitive to detect relatively swift changes in the populations, as well as regional variation in status. However, Ragni (1993a) cautions against unhesitating acceptance of survey results, finding a high degree of error (39%) among experts (zoologists, natural history museum curators, hunters, veterinarians, game wardens and professional naturalists) asked to distinguish between specimens of European wildcat and domestic cat.

According to P. Stahl (*in litt.* 1992), changes and trends in distribution are not well documented in most countries (Albania, Greece, Luxembourg, Poland, Portugal, Spain, Switzerland, Turkey, former Yugoslavia). In two countries, the species became extinct in the first half of the 20th century (Austria, Netherlands). In several west European countries (Belgium, France, Germany, United Kingdom), range expansion following World War II has been documented, although this expansion has now either halted, or continues at a very low rate. In these countries and in Italy, the range of the wildcat is generally considered stable, although local declines have been found in parts of Scotland (Easterbee *et al.* 1991). There seems to have been little change in wildcat populations in most east European countries (Bulgaria, Hungary, Romania), except in the Czech and Slovak Republics, where they have declined (P. Hell *in litt.* 1993).

A marked decrease in historical range has taken place in most of the former Soviet Union (Bannikov and Sokolov 1984, Belousova 1993, Muntyanu *et al.* 1993, Puzachenko 1993a). Wildcat populations are now found in three major areas: the Carpathian mountains of Ukraine (Bondar 1987, Turyanin 1988); the Kodry region of Moldova (Montyanu *et al.* 1993); and the Caucasus mountain region between the Black and Caspian seas (Belousova 1993, Puzachenko 1993a). The broad-leaved forest habitat of the Ukrainian Carpathians has been reduced by three- or four-fold over the last century (Tatarinov 1983). These easternmost *silvestris* populations are important because the level of hybridization with domestic cats is considered to be quite low (Heptner and Sludskii 1972; see discussion under Principal Threats below).

In northeastern France, Artois (1985) found that wildcats used daily ranges of 0.3-3.3 km^2. In the same study area, Stahl *et al.* (1988) found that seasonal home ranges of adult males were larger (5.7 ± 2.6 km^2; n=17) and more variable in size than those of females (1.8 ± 0.5 km^2; n=7). Resident male ranges overlapped 3-5 female ranges, but little overlap occurred between individuals of the same sex. In northeastern Scotland, however, Corbett (1979) found that males and females had equivalent average monthly home ranges (1.75 km^2), with little overlap. In western Europe, densities of 3-5 animals per 10 km^2 are reported from optimal forest habitats (review by Stahl and Leger 1992).

Stahl and Artois (1991) reviewed the results of several reintroduction attempts throughout Europe, and concluded that a long-term project run by the Bavarian Nature Conservancy Association in Germany was the best. Büttner (in press) states that 237 (136 males:101 females) captive-bred individuals were released from 1984 to 1993. Although there has been evidence of population establishment and natural reproduction, released individuals suffered high mortality during their initial weeks in the wild (due mainly to road kills), and the survival rate was estimated at about 30%. Stahl (1993) is of the opinion that, given the risks of hybridization, reintroduction should not be considered a priority for wildcat conservation: efforts should instead focus on protecting and supplementing small isolated populations.

Protection Status

CITES Appendix II. National legislation: fully protected over most of its range. Hunting prohibited: Armenia, Austria, Belgium, Czech Republic, France, Germany, Greece, Hungary, Italy, Luxembourg, Moldavia, Poland, Portugal, Spain, Switzerland, Turkey, United Kingdom, Ukraine. Hunting regulated: Azerbaijan, Romania, Slovakia. No legal protection (outside reserve areas): Bulgaria, Georgia, Romania. No information: Albania, Croatia, Slovenia, Yugoslavia (Stahl and Artois 1991, Ionescu 1993, Puzachenko 1993a, A. Bukhnicashvili *in litt.* 1993). Hunting is permitted in Slovakia from 1 Dec-28 Feb without restrictions. Total harvest has declined from about 900 in 1968-1970 to about 160 in 1991, and P. Hell (*in litt.* 1993) recommends at least a five-year moratorium to allow populations to recover.

Principal Threats

Hybridization between wildcats and domestic cats was first reported almost 200 years ago (Bewick 1807), and hybrids have been observed throughout Europe (Stahl and Artois 1991). However, the significance of the phenomenon is debatable. The importance of hybridization is diminished if *F. silvestris* is considered a polytypic species, and increased if the domestic cat is viewed as a separate species. Significant progress is being made in Europe towards defining the felid "units of conservation," combining studies of morphology (including pelage characters) and genetics to clarify the relationship between wildcats and domestic cats (Balharry and Daniels 1993, Crovella *et al.* 1993, Fernandes 1993, Kitchener *et al.* 1993, Ragni 1993a,b, Puzachenko 1993b). It is likely that hybridization in Europe is more advanced than in other regions of the wildcat's wide geographic range.

Suminski (1962, 1977) believed that "pure" forest wildcats were essentially extinct in Europe, having compared biological and morphological criteria among a large number of specimens. His findings have been disputed (Heptner and Sludskii 1972): Parent (1974), for example, believed that less than 2% of the Belgian population can be considered hybrid animals. Randi and Ragni (1986, 1991) concluded, on the basis of electrophoretic analyses and morphological data, that there is little probability of genetic flow between sympatric populations of forest wildcats and domestic cats.

Morphological and genetic studies of Scottish wildcats (Hubbard *et al.* 1992), on the other hand, point to frequent hybridization, although genetically distinct wildcats do remain in the remote areas of northern and western Scotland. The Scottish wildcat (*F.s. grampia*) was recognized by Haltenorth (1957) as the only valid subspecies in the *silvestris* group. Szemethy's (1993) radiotelemetry study in Hungary of sympatric wildcats (n=5) and feral domestic cats (n=6) provides data on how hybridization occurs and spreads. The feral cats' home ranges were smaller (0.8-1.7 km^2) and located near farms; the wildcats' home ranges were larger (1.5-8.7 km^2) and avoided the farms. However, during the breeding season, male wildcats shifted their home ranges to cover the territories of female farm cats. Szemethy (1993) also noted that some feral cats were able to live independently of the farms, and adapted to wildcat social structure.

Stahl and Artois (1991) recommend prioritizing investigations into the extent of hybridization in regions where past conditions were conducive to it, i.e. where:

- wild populations have shown a sharp drop in numbers over the past few decades;
- wildcat colonization is recent;
- wildcat populations are small and isolated;
- human population density is markedly increased, with a concomitant growth in numbers of domestic cats; and
- habitat transformation (intensive agriculture and forest plantations) is advanced.

Other threats highlighted by the survey of Stahl and Artois (1991) include habitat and population fragmentation; significant human-caused mortality, especially road kills; and vulnerability to diseases transmitted by feral cats. Clinical examinations by McOrist *et al.* (1991) suggest the possibility that feline leukemia virus (FeLV) occurs as a sustained infection in some Scottish populations, rather than as an occasional infection acquired from domestic cats. FeLV is transmitted readily among young cats via infected body fluids, such as during fighting or mating, and is almost always fatal. B. Ragni (*in litt.* 1993) believes that disease transmission, rather than hybridization, is the more serious threat resulting from the wildcat's contact with its domesticated relative.

Action Planning

Projects 10, 15, and 89-90.

Part I
Species Accounts

Chapter 5
The Americas

Box 1
Vulnerability Index to Species of the Region (in order of vulnerability)

Species	Habitat Association				Geog. Range (10^6 km^2)	Score	Body Size Score	Total Score	Ranking
	St	[Mar]	(Tot)	Score					
Kodkod, *O. guigna*	N: 2	[2]	(4)	-1	R: 0.16	-2	S +1	-2	1
Andean mtn. cat, *O. jacobitus*	N: 2	[0]	(2)	-1	R: 0.62	-2	S +1	-2	1
Jaguar, *P. onca*	I: 4	[3]	(7)	0	M: 8.91	0	L -1	-1	2(A)
Oncilla, *L. tigrinus*	N: 3	[1]	(4)	-1	S: 2.90	-1	S +1	-1	2
Margay, *L. wiedi*	N: 2	[3]	(5)	-1	M: 6.06	0	S +1	0	3
Canada lynx, *L. canadensis*	I: 4	[4]	(8)	0	M: 5.06	0	M 0	0	3
Geoffroy's cat, *O. geoffroyi*	I: 6	[1]	(7)	0	S: 2.80	-1	S +1	0	3
Puma, *P. concolor*	B: 8	[7]	(15)	+1	W: 17.12	+1	L -1	+1	4(A)
Ocelot, *L. pardalis*	I: 5	[4]	(9)	0	W: 12.45	+1	M 0	+1	4
Bobcat, *L. rufus*	B: 7	[4]	(11)	+1	M: 7.24	0	M 0	+1	4
Pampas cat, *O. colocolo*	B: 4	[6]	(10)	+1	S: 3.86	-1	S +1	+1	4
Jaguarundi, *H. yaguarondi*	B: 6	[4]	(10)	+1	W: 13.53	+1	S +1	+3	5

Key:

Habitat Association
St = number of strong + significant habitats
N = Narrow (-1); I = Intermediate (0); B = Broad (+1)
[Mar] = number of marginal habitats
(Tot) = total number of habitats

Geographic Range (in millions of km^2)
R = Restricted (-2); S = Small (-1); M = Medium (0); W = Wide (+1)

Body size
L = Large (-1); M = Medium (0); S = Small (+1).(A) = Actively threatened

Regional Criteria:
Habitat association: Narrow = 2-5 habitat types; Intermediate = 7-9 habitat types; Broad = 10-15 habitat types.
Geographic range: Restricted = ≤1 million km^2; Small = 2-4 million km^2; Medium = 5-9 million km^2;
Wide = 14-17 million km^2.
Body size: Large = 35-135 kg; Medium = 7-20 kg; Small = ≤6.5 kg.

See the Introduction to the Species Accounts for explanation of the vulnerability ranking system (pp. 2-6).

Kodkod, *Oncifelis guigna* (Molina, 1782)

Other Names

Guigna, chat du Chili (French); Chilenische Waldkatze, Nachtkatze (German); güiña (Spanish); gato de Santa Cruz, gato guiña (Argentina); huiña (Chile).

Description and Behavior (Plate 6)

The kodkod is the smallest felid in the Americas, weighing an average of 2.2 kg (n=3: Greer 1965a). It is a buffy to brownish cat heavily patterned with small black spots. The kodkod is closely related to Geoffroy's cat, of which it may be a subspecies—they do not appear to be sympatric (Hemmer 1978a). The subject deserves further investigation, particularly in Argentina, where Geoffroy's cat is more common and widely distributed, and has been collected near to the kodkod's known range (Redford and Eisenberg 1992, O.N. Herrera *in litt.* 1992). In comparison to Geoffroy's cat, the kodkod has a small face and much thicker tail (P. Quillen *in litt.* 1993). There is a high incidence of melanism (Cabrera and Yepes 1960, Osgood 1943, Greer 1965a) which, according to Miller and Rottmann (1976), increases with latitude, and is particularly common on Chiloé and Guaitecas islands. The kodkod has rather large feet, and well-developed arboreal abilities, sheltering in trees during inactive periods and climbing as an escape tactic when pursued (Housse 1953, Greer 1965a). Housse (1953) also notes that it dens in bamboo thickets.

Pearson (1983) examined the small mammal fauna of the southern Andean moist temperate forest, focusing on Argentina's Nahuel Huapi National Park, where the kodkod is known to occur. He found that this forest type, with which the kodkod is strongly associated (see below), has a high diversity of mouse-sized rodents, but lacks diversity of larger mammals, noticeably of the arboreal type (no squirrels or monkeys). Most of the small rodents are terrestrial, semi-fossorial, and diurnal. Kodkod stomachs have been found to contain remains of small rodents, Norwegian rat, and birds (Koslowsky 1904, Housse 1953, Greer 1965a). Kodkods have also been reported to take poultry (Guggisberg 1975, Melquist 1984). While believed to be primarily nocturnal (Miller and Rottmann 1976), Green (1991) notes that most activity takes place during the day in captivity.

The origin of the kodkod's name is obscure. It may be from one of the Mapuche Indian dialects, and probably originally referred to the pampas cat (*O. colocolo*)—"colocolo" may be a Spanish corruption of "kodkod" (F. Jaksic *in litt.* 1993). *O. guigna* is most commonly called the güiña (pronounced gwee-nya) in Chile and Argentina.

Biology

Gestation: (C) 72-78 days (P. Quillen *in litt.* 1993).

Litter size: (C) 1-3 (P. Quillen *in litt.* 1993); 3-4 (Housse 1953).

Longevity: (C) up to 11 years (Weigel 1975).

Habitat and Distribution

Found only in Argentina and Chile (Fig. 1), the kodkod is strongly associated with the moist temperate mixed forests of the southern Andean and Coastal ranges, particularly the Valdivian forest of Chile, which is characterized by the presence of bamboo in the understory (IUCN 1992a). It ranges up to the treeline at approximately 1,900 (Miller and Rottmann 1976) to 2,500 m (Melquist 1984). In Argentina, the kodkod has been recorded from moist montane forest which has Valdivian characteristics, including a multi-layered structure with bamboo, and numerous lianas and epiphytes (Dimitri 1972, N.O. Herrera *in litt.* 1992). Most records (nine out of 10 in Redford and Eisenberg 1992) coincide with the original distribution of temperate moist Araucarian and Valdivian forest (37-48° S: Udvardy 1975, C. Weber *in litt.* 1993). J. Rottmann (*in litt.* 1993) describes the kodkod's habitat associations in order of importance as (1) evergreen temperate rain forest, (2) deciduous temperate moist forest, (3) sclerophyllous scrub, and (4) coniferous forest.

Sclerophyllous scrub occurs in central Chile, from about 30-37° S (Udvardy 1975). Only one specimen has been collected from this habitat type, which is structurally and faunistically quite different from the Valdivian forest. That specimen (from the Valparaiso area, 33° S) was described as paler than the Valdivian kodkods, with a larger skull and heavier dentition. Osgood (1943), who classified the specimen as a separate subspecies (*O.g. molinae*), remarked on its similarity to the "salt desert" race of Geoffroy's cat, found in the Andes of northwestern Argentina, and speculated that further specimens might arise to link the two cats, although this has not occurred. In Chile, Geoffroy's cats are known to occur only in the *Nothofagus* beech forests of the far south, and this race of Geoffroy's cats bears little resemblance to the Valdivian kodkod (Cabrera 1961). It is puzzling that the kodkod should show such marked differences in habitat association, implying a broad habitat selectivity, and still have such a restricted distribution, implying narrow selectivity. Moreover, the kodkod is tolerant of altered habitats, being found in secondary forest and shrub as well as primary forest, and on the fringes of settled and cultivated areas. C. Weber (*in litt.* 1993) notes that the Valparaiso area, where the kodkod is still present, has been settled for over 1,000 years, and was deforested, except for small remnant patches, at least 150 years ago.

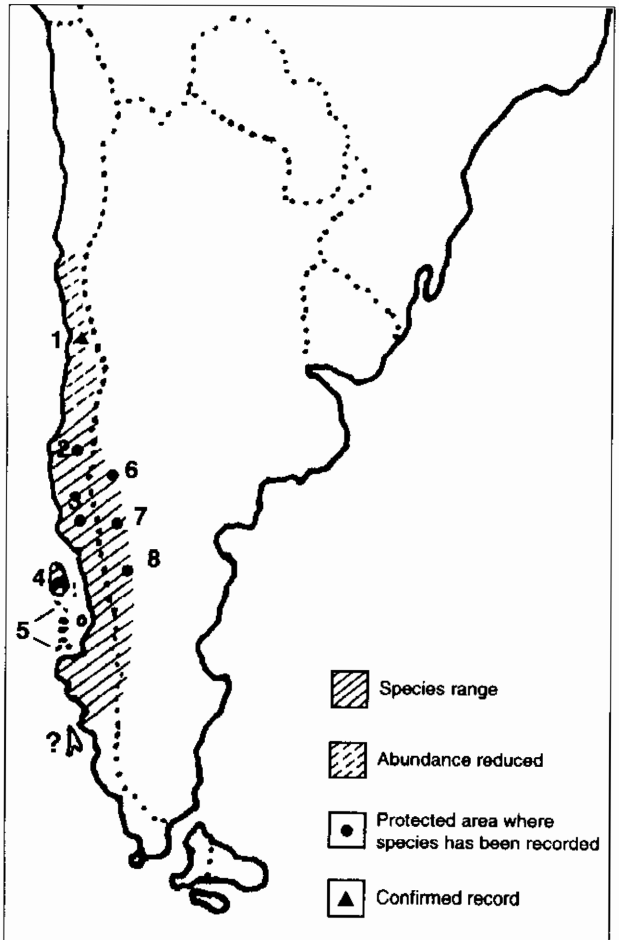

Figure 1. Distribution of the kodkod (*O. guigna*).
1. Valparaiso City (Osgood 1943, C. Weber *in litt.* 1993);
2. Conguillío II; 3. Puyehue II; 4. Chiloé II; 5. Las Guaitecas IV (Chile); 6. Lanín II complex; 7. Nahuel Huapi II complex; 8. Los Alerces II complex (Argentina).

Population Status

Global: Category 2. Regional: Category 1. IUCN: Indeterminate. The kodkod has historically been described as quite common (Osgood 1943, Cabrera and Yepes 1960). However, in the dry scrub of central Chile, 10% of the country's area but home to two-thirds of its population (Weber 1983), habitat loss has led to localized and patchy distribution (J. Rottmann *in litt.* 1993). In general, however, the southern forested part of its range is well protected and sparsely populated by humans. Even where its habitat has been altered, such as in central Chile, where 15,000 km^2 of pine and eucalyptus plantations have been established (C. Weber *in litt.* 1993), kodkods may do well as rodent populations thrive (J. Rottmann, pers. comm. in Melquist 1984).

The kodkod seems to live at higher densities on Chiloé Island (Melquist 1984), possibly linked to the absence of the puma, grey fox, and Andean fox (J. Rottmann *in litt.* 1993). In the mid-1800s, the German naturalist Philippi described groups of kodkods raiding chicken houses, with up to 20 cats being killed by farmers in a single day (Cabrera and Yepes 1960, Guggisberg 1975). Farmers there still complain of poultry depredation by the kodkod (Melquist 1984).

Protection Status

CITES Appendix II. National legislation: fully protected in Argentina and Chile (Fuller *et al.* 1987).

Principal Threats

Because of its restricted distribution, the kodkod is particularly vulnerable to habitat loss, the primary cause of reduced numbers in the north of its range. However, there is presently little forest clearance for agricultural purposes, and most monoculture plantations are being established on abandoned agricultural lands (C. Weber *in litt.* 1993). Logging of the Chilean Valdivian forest is increasing for export to Japan (Ancient Forest International [AFI] 1990, F. Jaksic *in litt.* 1993), but a substantial proportion (36%) is protected (WCMC 1992: 453), and logging is not necessarily a threat to the kodkod because of its use of secondary vegetation (J. Rottmann *in litt.* 1993). There are also several large protected areas within its range in Argentina (Melquist 1984, O.N. Herrera *in litt.* 1992). J. Rottmann (*in litt.* 1993) mentions fox hunting (both legal and illegal, with dogs and traps) as a potential threat, citing unpublished data showing that 1-5% of fox hunter kills are small cats. Melquist (1984), however, only once saw a garment of what appeared to be kodkod pelts in a local market.

Action Planning

Project 91.

Andean mountain cat, *Oreailurus jacobitus* (Cornalia, 1865)

Other Names

Chat des Andes (French); Andenkatze, Bergkatze (German); chinchay, gato andino, gato lince (Spanish); gato montés altiplánico, titi (Bolivia); gato montés andino (Chile); osjo (Peru).

Description and Behavior (Plate 6)

There are just a few museum skins and skulls by which to describe this species, and there have been just a handful of observations made in the wild (Grimwood 1969, Scrocchi and Halloy 1986, Ziesler 1992). The Andean mountain cat is a small but sturdy cat: one male from Peru weighed 4 kg (Pearson 1957). It has long ash-grey fur indistinctly patterned with rusty rosette-like spots on the sides, and marked with conspicuous thick dark stripes extending down the sides from the back. Prominent dark grey bars run also across its chest and forelegs. Its nose is black, and its belly pale, with dark spots. The tail is thick and long (about 70% of head-body length: Osgood 1943, Pearson 1957, Cabrera 1961, Pine *et al.* 1979), banded with approximately seven conspicuous dark rings. The mountain cat is characterized by large auditory bullae of a form unique among the felids, the anterior chamber being somewhat larger than the posterior (Kuhn 1973). Enlarged auditory bullae are typical of animals inhabiting arid environments with little cover for protection and concealment (see description of the sand cat under *North Africa and Southwest Asia*).

Essentially nothing is known about the biology and behavior of the Andean mountain cat. The most detailed observation of it in the scientific literature was made at 4,250 m in the northeast of Argentina's Tucuman province (Scrocchi and Halloy 1986). A single cat was followed on foot for more than two hours during late morning at a distance of 15 to 50 m, showing no fear of humans. It drank from melting ice, and moved to sit upon a prominent rock. A gray fox ran from the cat. The cat travelled further and rested in the shadows on a rocky hillside before it moved out of sight.

Halloy (1985) suggests that the Andean cat may be more active on full moon nights, with more daylight activity during the new moon. Winters probably represent critical periods of increased hardship for the Andean mountain cat.

Burmeister (1879) reported without elaboration that the Andean mountain cat prefers to hunt mountain chinchillas (nocturnal) and mountain viscachas (diurnal). Grimwood (1969) and Ziesler (1992) each observed a cat stalking mountain viscachas at 4,000-4,300 m. These remain the only clues to its diet, which may or may not include other species (birds, reptiles, small rodents, etc.). The mountain cat's range appears to coincide with the original distribution of these large rodent species. Both are "ricochettal" rodents: their strategy to escape predators involves making unpredictable changes of direction by bounding off rock faces (MacClintock 1966). Like the Andean mountain cat, the mountain chinchillas and viscachas have enlarged auditory bullae. The long tail of the mountain cat (which is much longer than that of the similar-looking montane form of the pampas cat [Redford and Eisenberg 1992]) is probably an aid to balance when chasing these rodents. Other species with relatively long thick tails include the cheetah (gazelles and hares change directions swiftly during high-speed chase as an escape strategy), the snow leopard (which hunts mountain goats and sheep among cliffs and crags), and the clouded leopard, marbled cat, and margay (species with highly developed arboreal capabilities).

Biology

No information. No animals known to be kept in captivity.

Habitat and Distribution

The Andean mountain cat is apparently very specialized in its habitat requirements, having been found only in the rocky arid and semi arid zones of the high Andes above the timberline (generally above 3,000-4,000 m in elevation). Vegetation at observation and collection sites has consisted mainly of small scattered dwarf shrubs and clumps of bunchgrass (Pearson 1957, Scrocchi and Halloy 1986). The presence of rock piles and boulders (typical microhabitat of mountain viscachas, and the only type of cover available at such altitudes) may be important (Scrocchi and

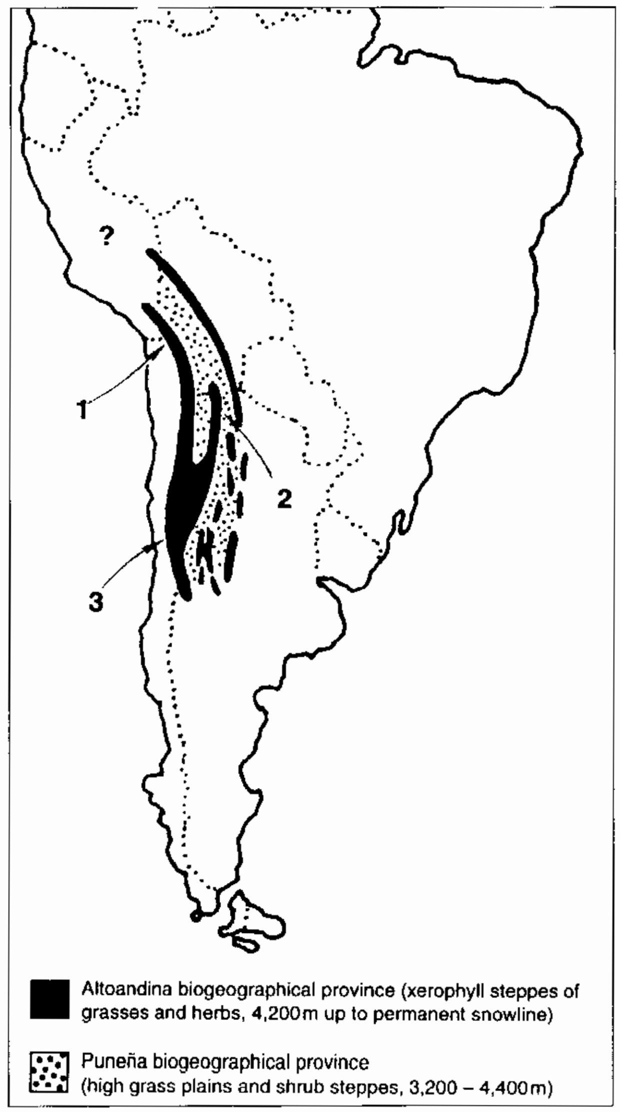

Figure 2. Distribution of the Andean mountain cat (*O. jacobitus*). Protected areas where *O. jacobitus* may occur: 1. Lauca II* complex (Chile); 2. Los Andes I; 3. San Guillermo IV* complex (Argentina).

Halloy 1986, Ziesler 1992). Figure 2 shows the area of the Puna (grassland) and Altoandina high-altitude biogeographic provinces (Cabrera and Willink 1980), within the range delimited by *O. jacobitus* collection and sighting records (Grimwood 1969, Melquist 1984, Scrocchi and Halloy 1986, Redford and Eisenberg 1992). The distribution of these habitat types is more patchily distributed than shown, as the high plateau is broken up by deep valleys.

Population Status

Global: Category 2. Regional: Category 1. IUCN: Insufficiently Known. Andean mountain cats apparently occur at low densities.

Protection Status

CITES Appendix I. National legislation: fully protected over its range. Hunting and trade prohibited: Argentina, Bolivia, Chile, Peru (Fuller *et al.* 1987).

Principal Threats

It is not clear whether the apparent rarity of the Andean mountain cat is a natural phenomenon, is attributable to human actions, or is simply a misperception resulting from lack of observations. Only a detailed study of its ecology will provide the answer, but in the meantime, speculation will have to suffice.

Lack of knowledge is obviously a factor. The few observations of the species were all in the daytime, and details regarding collection or observation, typically made during general mammal surveys, are sparse (e.g., Pearson 1957, Greer 1965b, Grimwood 1969, Pine *et al.* 1979, Melquist 1984). With regard to human action, it appears that two of the usual human-induced causes of rarity—habitat loss/modification and direct persecution—are only partially responsible. There have been no significant changes in land-use of the high Andes over the last 2,000 years—if anything, the human population has decreased (S. Halloy *in litt.* 1993, C. Weber *in litt.* 1993). Grazing by domestic camelids, sheep, and goats can lead to reduced densities of large rodents, but at present this problem is localized rather than widespread (Holdridge 1978, J. Rottmann *in litt.* 1993). Large dogs, feral or accompanying livestock, may chase and frighten Andean cats. In terms of hunting pressure, herders usually carry guns when accompanying grazing animals, and pelts of Andean mountain cats are occasionally seen in fur markets (Melquist 1984, A. Ximenez *in litt.* 1991, S. Halloy *in litt* 1993, J. von Thungen, pers. comm.). Yet C. Weber (*in litt.* 1993) notes that the high Andes Indians of northern Chile knew little of the species, and that all the pelts he observed which were kept for ceremonial purposes were of the pampas cat. There are no records of international trade (aside from one probably misidentified trans-European shipment in 1977: WCMC unpubl. data).

It is possible that the Andean mountain cat is rare because it has evolved to be a specialized predator of chinchillids. Both mountain chinchillas and mountain viscachas have naturally patchy distributions, living in small colonies (the biggest viscacha colonies contain only around 60 animals [Ziesler 1992]). The colonies are centered around cliffs and boulders, and the animals avoid extensive areas of open ground. Moreover, the high mountain habitat types are also unevenly distributed in some parts of the Andes, where the high plateau is dissected by deep valleys which are better watered, more thickly vegetated and relatively heavily settled—not characteristic mountain cat habitat (Scrocchi and Halloy 1986).

More specifically, perhaps the Andean mountain cat evolved to hunt nocturnal chinchillas rather than the larger, diurnal viscachas (few cats are diurnal, and neither of the two observed hunts were successful). While mountain viscachas are declining locally outside of reserves due to subsistence hunting (H. Torres *in litt.* 1991, J. Rottmann *in litt.* 1993), the short-tailed chinchilla has been hunted to the brink of extinction. It was intensively exploited for the European fur trade from the late 19th to the early 20th centuries. Formerly ranging through the high Andes from northern Peru south to the vicinity of Santiago, only a few scattered colonies are believed to survive in rugged and inaccessible terrain where the borders of Argentina, Boliva, Chile and Peru meet (at about 23° S) (Thornback and Jenkins 1982, Gudynas 1989).

If the Andean mountain cat has indeed specialized to prey on chinchillas, widespread extinction of colonies must have had disastrous effects. On the other hand, if it is not a specialist predator, small prey biomass is high in the Andean uplands (A. Canedi, C. Weber *in litt.* 1993), and its rarity must be attributed to the other factors.

Action Planning

Project 92.

Jaguar, *Panthera onca* (Linnaeus, 1758)

Other Names

Jaguar (French); Jaguar (German); tigre, tigre real, yaguar (Spanish); onça, onça pintada, onça canguçu (Brazil); tig marqué (French Guiana); yaguareté (Guaraní); zac-bolay (Mayan); jaguareté (Paraguay); otorongo (Peru); penitigri (Suriname); yaguar (Venezuelan); onça negra, yaguara pichuna, yagua-hu (black jaguars).

Description and Behavior (Plate 4)

The jaguar is the largest cat of the Americas, and the only living representative of the genus *Panthera* found in the New World. The jaguar's pattern differs from that of the leopard by having larger, broken-edged rosettes around small black spots. It has a large head and stocky build, with relatively shorter limbs than others of its genus (Gonyea 1976). Melanism is frequent in the jaguar, and is inherited as a monogenic dominant to the normal golden-colored form, rather than through a recessive allele (Deutsch 1975, Dittrich 1979). Albinistic specimens are occasionally reported (Seymour 1989). Forest jaguars are not only more frequently darker, but are also considerably smaller in size than animals which inhabit more open areas. In central American rain forest, 13 males averaged 57 kg and seven females 42 kg (Rabinowitz and Nottingham 1986, Aranda 1990), while in the Brazilian Pantanal males averaged 100 kg (n=24) and females 76 kg (n=16) (de Almeida 1984). The size difference may be due to the greater abundance of large prey species in more open environments.

More than 85 species have been recorded in the jaguar's diet (Seymour 1989). Large prey, such as peccaries, tapirs and deer, may be preferred, but a jaguar will eat almost anything it can catch, and in the rain forest will take mammal prey species in proportion to their occurrence (Rabinowitz and Nottingham 1986, Emmons 1987). Large herbivores are more thinly distributed in rain forest than in more grassy, open habitats, where they are more likely to form groups and cluster near water, and jaguar diet in the rain forest and in savannah woodlands reflects this difference in prey availability and vulnerability (Emmons 1991). In many areas, cattle are ranched on what is essentially prime jaguar habitat, and cattle have been the most frequent prey species documented in several analyses of jaguar diet in Brazil (A. Almeida in Hoogesteijn *et al.* 1993, Crawshaw and Quigley in prep.) and Venezuela (Hoogesteijn and Mondolfi 1992).

Jaguars are the only big cats which regularly kill prey (especially capybaras) by piercing the skull with their canines (Schaller and Vasconcelos 1978, Mondolfi and Hoogesteijn 1986, Crawshaw and Quigley in prep.). Emmons (1987) suggests that the massive head and stout canines of the jaguar are an adaptation to "cracking open" well-armored reptilian prey, such as land tortoises and river turtles. She notes that, following the late Pleistocene extinctions of large herbivores, the jaguar and the puma were the only representatives of five genera of North American felid to persist, and speculates that the jaguar evolved to take advantage of a formerly super-abundant prey base of water reptiles.

Although the jaguar has been characterized as primarily nocturnal (e.g., Nowak and Paradiso 1983), radiotelemetry has shown that they are often active during the daytime, with activity peaks around dawn and dusk. Jaguars have been found to be active for 50-60% of each 24-hour period (Schaller and Crawshaw 1980, Rabinowitz and Nottingham 1986, Crawshaw and Quigley 1991). Crawshaw and Quigley (1991) found that mean daily travel distance was significantly larger for a male (3.3+1.8 km) than for females (1.8 ± 2.5 km). Both sexes tended to travel further each day during the dry season. Rabinowitz and Nottingham (1986) found that radio-collared male jaguars tended to remain within small areas (average 2.5 km^2) for a week at a time before shifting in a single night to other parts of their range.

Biology

Reproductive season: (W) probably year-round, but Rabinowitz and Nottingham (1986) reported that young are usually born in the rainy season when prey is more abundant, hence seasonal birth peaks reported in other areas (e.g., January-April in Venezuela [Hoogesteijn and Mondolfi 1992]) may be correlated with prey availability.

Estrus: (C) 6-17 days.

Estrus cycle: (C) average 37 days, range 22-65 days (Sadleir 1966, Stehlik 1971, Leal 1979).

Gestation: (C) average 101, range 91 -111 days (Hemmer 1976).

Litter size: (C & W) 1-4, mode 2 (Hoogesteijn and Mondolfi 1992).

Age at independence: (W) 1.5-2 years.

Age at sexual maturity: (C) 2-3 years, females; 3-4 years, males (Mondolfi and Hoogesteijn 1986).

Longevity: (W) 11-12 years (A. Rabinowitz, unpubl. data, in Swank and Teer 1987); (C) up to over 20 years (Green 1991).

Habitat and Distribution

The jaguar, which swims well, is strongly associated with the presence of water. Habitats meeting this requirement range from rain forest to seasonally flooded swamp areas (Pantanal and Llanos), pampas grassland, thorn scrub woodland (Chaco), and dry deciduous forest. In Belize, Rabinowitz (1991a) found that jaguars were more abundant in lowland areas of relatively dense forest cover with permanent water sources than in open, seasonally dry forests. In the Brazilian Pantanal, riparian forest was strongly preferred to open grassy areas (Crawshaw and Quigley 1991). Although jaguars have been reported from elevations as high as 3,800 m (Costa Rica: Vaughan 1983), jaguars typically avoid montane forest (Emmons 1991), and have not been found in the high plateau of central Mexico (Leopold 1959) or above 2,700 m in the Andes (Guggisberg 1975, Olrog and Lucero 1981).

The historical range of the jaguar extended from

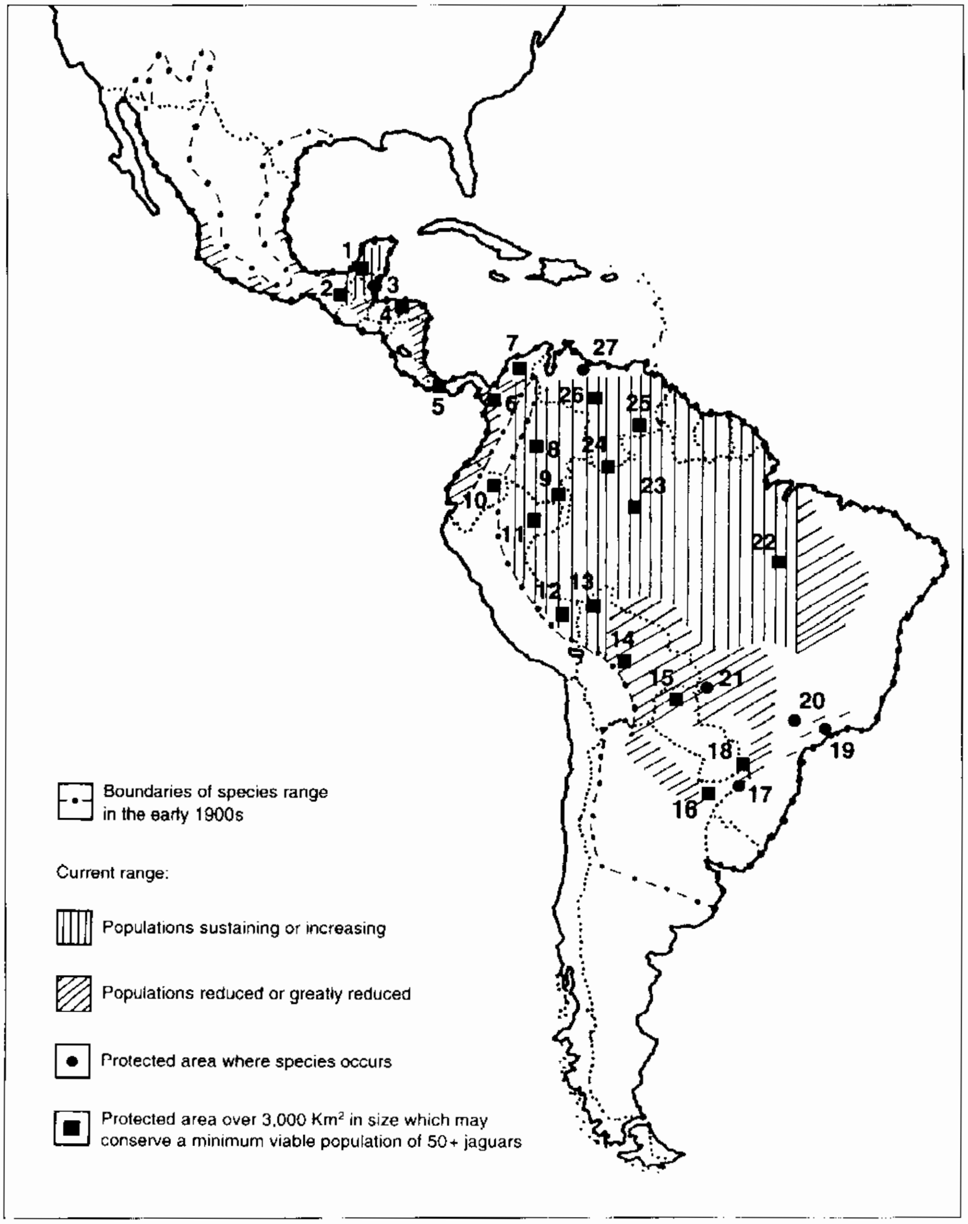

Figure 3. Past and present distribution and relative abundance of the jaguar (*P. onca*) after Swank and Teer (1987).
1. Calakmul V* (Mexico) + Maya IX* (Guatemala); 2. Montes Azules II (Mexico); 3. Cockscomb Basin IV (Belize); 4. Rio Platano IX# (Honduras); 5. La Amistad (Talamanca) II# complex (Costa Rica and Panama); 6. Darién II# complex (Panama) + Los Katios II (Colombia); 7. Sierra Nevada de Santa Marta II* complex; 8. Sierra de la Macarena II complex; 9. Cahuinarí II complex (Colombia); 10. Yasuni II* (Ecuador); 11. Pacaya Samiria VIII; 12. Manú II# (Peru); 13. Manuripi Heath IV complex; 14. Isiboro Sécure II (Bolivia); 15. Defensores del Chaco II (Paraguay); 16. Iber IV complex (Argentina); 17. Moconé Provincial Reserve (Argentina) + Turvo II (Brazil) complex; 18. Iguazú II** (Argentina) + Iguaçu II** (Brazil) complex; 19. Juréia-Itatins IV; 20. Alto Ribcira II complex; 21. Pantanal Matogrossense II; 22. Araguaia II complex; 23. Jau II complex (Brazil); 24. Pico da Neblina II (Brazil) + Serranía de la Neblina II (Venezuela) complex; 25. Canaima II; 26. Aguaro-Guariquito II; 27. Henri Pittier I (Venezuela).

Arizona, New Mexico, and Texas in the United States south to either the Río Negro (40° S) or Río Santa Cruz (50° S) in Argentina (Arra 1974, Carman 1984). Formerly occupied habitat in the north of its range included oak woodland, mesquite thickets, and riparian forests (Brown 1991). In the north, the jaguar's range has receded southward about 1,000 km, and has been reduced in area by about 67%. In South America, the jaguar's range has receded northward by well over 2,000 km, and has been reduced by about 38% (Swank and Teer 1987).

Population Status

Global: Category 3(A). Regional: Category 2(A). IUCN: not listed. The Amazon basin rain forest, some 6 million km² in extent (Collins 1990), is the key stronghold of the species, and densities may be as high as one resident per 15 km², as estimated for jaguars in Belize (Rabinowitz 1991). This refuge is of sufficient size and integrity to conserve the species in large numbers for well into the forseeable future, even if densities are lower than in Belize. However, the jaguar is declining in most other habitats (Fig. 3). It has been virtually eliminated from much of the drier northern parts of its range in the U.S. and Mexico (Brown 1991), as well as the pampas scrub grasslands of Argentina and throughout Uruguay (Swank and Teer 1987). The species has probably already lost significant elements of its intraspecific diversity, and the trend continues. While commercial exploitation for their skins is no longer a factor, jaguars still face local extirpation at the hands of cattle ranchers.

The status of several key large jaguar populations is discussed in detail below.

1. *Yucatan peninsula/northern Guatemala/Belize:* Rabinowitz and Nottingham (1986), working in the Cockscomb Basin of Belize, found male home ranges to average 33 km^2 (range 28-40 km^2; n=4) and females a minimum of 10 km^2 (n=3). There was partial overlap of male ranges, no overlap of female ranges, and male ranges entirely encompassed those of females. Based on a mean density of one resident adult jaguar per 15 km^2, and taking land and hunting pressures into account, Rabinowitz (1991a) estimated Belize's population to number between 600 to 1,000. Based on density estimates (derived from footprints) of one jaguar per 26-32 km^2 in Mexico's Calakmul Biosphere Reserve, Aranda (1990) estimated a population of 125-180 jaguars for the 4,000 km^2 reserve, and 465-550 jaguars in an adjoining 15,000 km^2 of wilderness area in Petén, northern Guatemala—which has since been protected as the Maya Biosphere Reserve.

2. *Chiapas state, Mexico:* Aranda (*in litt.* 1993) estimated 350 ± 65 jaguars (based on a range of habitat-specific densities from one animal per 15-40 km^2) in the state, concentrated in four major populations occupying a total of 8,800 km^2.

3. *The Pantanal:* The Pantanal is the largest seasonally flooded land area in the world (Alho *et al.* 1988), extending over 100,000 km^2 on the borders of Brazil, Bolivia and Paraguay. Wet savannah woodland such as this and the Venezuelan llanos may represent optimal jaguar habitat, judging by the larger average sizes attained by jaguars in these areas. However, the economy and culture revolves around cattle ranching in both areas, and jaguar numbers have been greatly reduced. Quigley and Crawshaw (1992) estimated jaguar density at only 1.4 resident adults per 100 km^2 in the Brazilian Pantanal, where relatively undisturbed, intact populations exist only in the north-central and extreme southern parts of the region, separated by over 150 km.

   Resident jaguar annual home ranges averaged 142 km^2 (n= four females, one male). The male's home range was not larger than the females'. Female home ranges overlapped an average of 11.5% during the dry season, but not the wet. Mean wet season home range (13 km^2) was significantly smaller than during the dry season due to extensive flooding; jaguars used only 4-13% of their total annual ranges during the wet (Crawshaw and Quigley 1991).

4. *Paraguayan Gran Chaco:* The Chaco thorn scrub is probably the only remaining place where jaguars occur in significant numbers in an arid environment. Redford *et al.* (1990) estimated that 176,000 km^2 of viable habitat remain in the Paraguayan Chaco, an historical loss of 45%, with deforestation accelerating. Brooks (1990) relays reports of Paraguayan biologists that jaguar populations are recovering from the depredations of the skin trade. Although the ecology of the species has not been studied, various density estimates for the region have been put forward, ranging from one jaguar per 25 km^2 to one per 75 km^2 (in Swank and Teer 1987).

Protection Status

CITES Appendix I. National legislation: fully protected over much of its range. Hunting prohibited: Argentina, Brazil, Colombia, French Guiana, Honduras, Nicaragua, Panama, Paraguay, Suriname, United States, Uruguay, Venezuela. Hunting restricted to "problem animals": Brazil, Costa Rica, Guatemala, Mexico, Peru. Trophy hunting permitted: Bolivia. No legal protection: Ecuador, Guyana (Swank and Teer 1987, Fuller *et al.* 1987, Anon. 1989d).

Occurrence in Protected Areas:

Quigley and Crawshaw (1992) estimated that at least 3,200 km^2 of protected habitat would be required to support a minimum population of 50 jaguars in the Pantanal region. Protected areas over 3,000 km^2 in size are marked with a square in Fig. 3; other smaller but strategically located areas known to contain jaguar are also shown. Isolated remnant populations are scattered through the fragmented Atlantic coastal forests of southeastern Brazil, located in reserves (IUCN 1982) and also in unprotected areas, including the Serra de Paranapiacaba Mountains southwest of Sao Paulo (J. Guix *in litt.* 1993).

Principal Threats

Deforestation rates are highest in Latin America (FAO 1993), and fragmentation of forest habitat isolates jaguar populations so that they are more vulnerable to the predations of man. People compete with jaguars for prey (Jorgenson and Redford 1993), and jaguars are frequently shot on sight, despite protective legislation. The most urgent conservation issue is the current intolerance of ranchers for jaguars (see Part II, Chapter 2 for more discussion of this issue). In many cattle-ranching operations in the region, livestock roam widely and become essentially feral (Schaller 1983, Quigley and Crawshaw 1992). Cattle have been shown to constitute a major portion of jaguar diet in studies carried out on ranches in seasonally flooded savannah woodland (Hoogesteijn *et al.* 1993, Crawshaw and Quigley in prep.). The vulnerability of the jaguar to persecution is demonstrated by its disappearance by the mid-1900s from the southwestern U.S. and northern Mexico, areas which are today home to important puma populations (Brown 1991). A conservation plan has been developed for jaguars in the Brazilian Pantanal (Quigley and Crawshaw 1992), and the Brazilian government is planning to establish a National Center for Research, Management, and Conservation of Predators in Brazil to address livestock-predator problems (P. Crawshaw, pers. comm.). Swank and Teer (1988) emphasize the potential benefits of controlled sport hunting as an element of national jaguar conservation strategies, arguing that trophy fees would be an incentive for some ranchers to maintain jaguars on their land. Translocation of problem jaguars has also been recommended (Anon. 1992c, 1993c). Preliminary results from one such attempt in Brazil have been good (P. Crawshaw *in litt.* 1993), but Rabinowitz (1986) found that translocated jaguars in Belize often returned to stock killing.

Commercial hunting and trapping of jaguars for their pelts has declined drastically since the mid-1970s, when anti-fur campaigns gathered steam and CITES controls progressively shut down international markets (see Part II Chapter 4). Organized poaching rings, in which fur buyers travelled through the country supplying traps and buying pelts from local people, are a thing of the past (Swank and Teer 1987).

Action Planning

Projects 6 and 93-95.

Oncilla, *Leopardus tigrinus* (Schreber, 1775)

Other Names

Little tiger cat, little spotted cat (English); chat tigre, oncille, (French); Onzille, Kleinflekenkatze, Ozelotkatze, Zwergtigerkatze (German); tigrillo, tirica, gato tigre (Spanish); gato tigre chico, gato onza chico, gato pintado chico (Argentina); gato do mato (Brazil); chivi (Argentina, Guyana, Peru); tigrillo peludo, tigre gallinero (Colombia); caucél (Costa Rica); tigrillo chico (Ecuador); chat tigre tacheté, chat tig (French Guiana); ocelot-cat, tigrikati (Suriname); tigrito (Venezuela).

Description and Behavior (Plate 5)

With a silhouette and footprint resembling a house cat, the oncilla is small, having an average weight of 2.2 kg (n=3: Redford and Eisenberg 1992), with males slightly larger than females (Guggisberg 1975). The oncilla closely resembles the margay, and the two can be difficult to distinguish in the field (Vaughan 1983). The two cats are similarly marked, but the oncilla's pattern of rosettes tends to be less dark and blotchy than the margay's, its fur is not as thick, its body is more slender, and its tail not as long (TL=26.9 cm, 56% of head-body length, n=13: Redford and Eisenberg 1992). Melanistic individuals are occasionally reported (Mondolfi 1986, Eisenberg 1990, P. Quillen *in litt.* 1993). Prey taken from stomachs (n=3) has consisted of small mammals (rodents and shrews) and a passerine bird (Gardner 1971, Mondolfi 1986). Oncillas have been reported to prey on small primates in Brazil (P. Quillen *in litt.* 1993). J. Guix (*in litt.* 1993) analyzed the contents of one stomach and five scats from Brazil's Atlantic coastal rain forest, and found feathers and hair from small mammals (rats and possibly one mouse opossum). Four oncillas were captured there in unbaited live traps set along armadillo trails.

Biology

Gestation: (C) 55-60 days (Widholzer *et al.* 1991 - 75-78 days (Leyhausen and Falkena 1966).

Estrus: (C) 3-9 days, with older cats having shorter cycles (Foreman 1988).

Litter size: (C) 1-3, one most common (Leyhausen and Falkena 1966, P. Quillen *in litt.* 1993).

Longevity: (C) average 11, but up to over 17 years (Prater *et al.* 1988, P. Quillen *in litt.* 1993).

Habitat and Distribution

The oncilla shows a strong preference for montane cloud forest (Mondolfi 1986), in that it is found at higher elevations than the ocelot and margay. For example, Melquist (1984) reports that it is restricted to elevations above 1,500 m in Colombia, and has been found at up to 4,500 m, approximately snowline. Rodríguez and Paz y Miño (1989) also note that it has only been collected from the Andean highlands in Ecuador, a zone where the puma and pampas cat occur. Most specimens collected in Costa Rica (5 of 6) have been taken in cloud forest (Gardner 1971, Vaughan in press). In eastern Brazil, Koford (1973) remarked on its presence in the subtropical forest highlands, and J. Guix (*in litt.* 1993) reports it from early secondary forest and abandoned eucalyptus plantation at 600 m elevation, in areas close to human settlement and highly affected by deforestation and fire. Oliveira (1994) reported oncillas from semi-arid thorny scrub in northeast Brazil. Bisbal (1989) also notes records from dry deciduous forest in northern Venezuela. To what degree the oncilla uses lowland moist forest is not clear, especially within the Amazon basin. It has not been reported from this area (J. Eisenberg *in litt.* 1993) and, according to L. Emmons (*in litt.* 1993), is unlikely to occur there. However, there are several records from the outer edges of the Amazon rain forest (Fig. 4), mainly from riverine forest (Mondolfi 1986, Eisenberg 1990).

The oncilla appears to have a naturally disjunct distribution, although further research is necessary to confirm

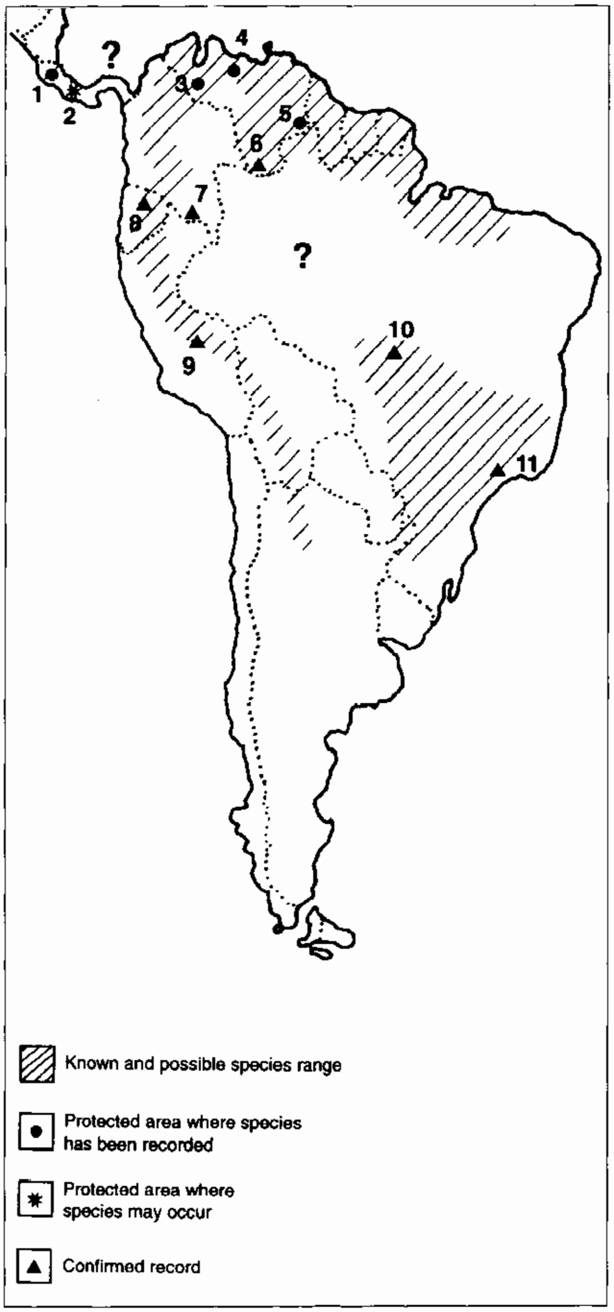

Figure 4. Possible distribution of the oncilla (*L. tigrinus*). 1. Tapantí IV (Costa Rica: Vaughan in press); 2. La Amistad II* (Costa Rica and Panama: Melquist 1984); 3. Sierra Nevada II complex; 4. El Avila II; 5. Canaima II (R. Hoogesteijn *in litt.* 1993); 6. Specimen collected near Isla Chicharral, Río Negro, Amazonas (Mondolfi 1986) (Venezuela); 7. Record from Río Caqueta, lowland gallery forest (Colombia: Eisenberg 1990); 8. Specimen collected from C. Ilaló, 2,800 m (Ecuador: Rodríguez and Paz y Miño 1989); 9. Specimen collected from La Florida, Region Alto Yurinaqui, Junín, 800 m (Peru: V. Pacheco *in litt.* to L. Emmons); 10. Specimen collected from northern Mato Grosso (Pine *et al.* 1970); 11. Four specimens collected from secondary forest scrub on the outskirts of São Paolo (J. Guix *in litt.* 1993) (Brazil).

this. The northernmost record is from northern Costa Rica, near the Tapantí Cloud Forest Faunal Refuge (Vaughan in press). It has been recorded from northern Panama (Melquist 1984), but the remainder of the country appears to be a gap in the species' range (Eisenberg 1990). Gardner (1971) commented on the similarity of appearance of Costa Rican cats to one collected in Colombia, and this moved Melquist (1984) to state that the oncilla is probably found throughout Panama, as habitat there is suitable. There are only two museum specimens for Ecuador and Peru (Rodríguez and Paz y Miño 1989, V. Pacheco *in litt.* to L. Emmons). There are no museum records for Bolivia, although K. Cassaro has reported seeing captive animals originating from that country (pers. comm. to P. Quillen 1992). Figure 4 shows potential distribution if the oncilla is assumed to be absent from the Amazon basin, and otherwise present only in montane and subtropical forest.

Population Status

Global: Category 3. Regional: Category 2. IUCN: Insufficiently Known. This species has never been studied in the wild, and there is little understanding of its habitat requirements, density, and coexistence with other small cats. It has been trapped in large numbers for the fur trade—in 1971, 28,000 pelts were counted in Brazilian warehouses, and in 1983, 84,500 skins were exported from Paraguay (Broad 1988)—although it is likely that other spotted cat pelts were mixed with oncilla. It is rarely seen by field biologists.

Protection Status

Upgraded to CITES Appendix I in 1989. National legislation: protected over part of its range. Hunting prohibited: Argentina, Brazil, Colombia, Costa Rica, French Guiana, Paraguay, Suriname, Venezuela. No legal protection: Ecuador, Guyana, Nicaragua, Panama, Peru (Fuller *et al.* 1987).

Principal Threats

It is difficult to assess threats to the oncilla when so little is known about it. Coffee plantations are often established in cloud forest habitat (Melquist 1984), but J. Guix's (*in litt.* 1993) observations of it in deforested areas and eucalyptus monoculture on the outskirts of São Paolo suggest tolerance of habitat alteration. Although international trade effectively ceased after 1985 (WCMC unpubl. data), 675 spotted cat skins, mainly oncilla, were seized in Brazil, but came from Paraguay. The age of the pelts, however, was not ascertained (P. Crawshaw, A. Ximénez *in litt.* 1991).

Action Planning

Projects 96 and 97.

Margay, *Leopardus wiedi* (Schinz, 1821)

Other Names

Margay (French); Langschwanzkatze (German); tigrillo, gato tigre (Spanish); gato pintado (Argentina, Peru, Venezuela); tigrillito (Belize); gato montés, gato de monté (Bolivia, Uruguay); gato maracaja mirim peludo (Brazil); pichigueta (Cent. Am.); caucel (Costa Rica, Honduras); burricón (Ecuador); mbaracaya (Guatemala); kuichua (Guyana); chat tig, chat margay (French Guiana); chulul (Mayan); huamburushu (Peru, Venezuela); cunaguaro (Venezuela); tigrikati, boomkat [tree cat] (Suriname).

Description and Behavior (Plate 5)

The margay is easily confused with the ocelot and the oncilla. It is difficult to distinguish by its coat, which is patterned with black-ringed rosettes and elongate blotches on a tawny background. Its fur is thick and plush. The margay is between the two in size, weighing an average of 3.2 kg (n=4: Redford and Eisenberg 1992). In motion, however, the margay displays exceptional climbing abilities. It has the ability to rotate its hind foot through 180° (Leyhausen 1963). Thus equipped, it can run straight down trees head-first like a squirrel, and may hang from a branch by one hind foot. In the early 1800s, Maximilian Prince zu Wied observed the margay climbing about on dangling lianas in the forest (Weigel 1975). Petersen (1977a) describes the acrobatics of captive margays on a rope strung horizontally in their enclosure. The cats would jump from a distance of 2 m with front legs and claws extended, hit the rope at their belly region, somersault over to hang by the hind feet, and drop back to the ground. The margay's tail is proportionately quite long (although not as long as the Andean mountain cat), averaging 70% of head-body length (TL=36.4 cm; n=6: Redford and Eisenberg 1992). It serves as a counterweight to aid balance (Eisenberg 1990).

In Belize, a radio-collared margay was found to forage in trees, but travel on the ground (Konecny 1989). Based on analysis of 27 scats, the most common item in the diet was a small arboreal mammal, the big-eared climbing rat. Squirrels, opossums, arthropods, small birds, and fruit were also taken (Konecny 1989). Other reported arboreal prey includes prehensile-tailed porcupines, marmosets, capuchin monkeys, and three-toed sloths (Goldman 1920, Beebe 1925). Terrestrial prey has also been reported, including spiny pocket rats, cane rats, and cavies (Carvalho 1958, Mondolfi 1986), but in the Belize study margays took more birds and fruit and fewer terrestrial mammals than ocelots or jaguarundis (Konecny 1989). Margays are strongly nocturnal, with highest levels of activity recorded between 0100-0500 both in the wild and captivity; during the daytime, they rest in trees (Petersen 1977a, Konecny 1989).

Biology

Estrus: (C) 4-10 days.

Estrus cycle: (C) 32-36 days (Petersen 1977b, Paintiff and Anderson 1980, Mellen 1989).

Gestation: (C) 76-84 days (Paintiff and Anderson 1980, Mellen 1989, P. Quillen *in litt.* 1993).

Litter size: (C) one (n=17: Mellen 1989), sometimes two (Mondolfi 1986).

Age at sexual maturity: (C) first estrus for females at 6-10 months (Petersen and Petersen 1978).

Longevity: (C) up to 20 years (Prator *et al.* 1988).

Habitat and Distribution

The margay is more strongly associated with forest habitat, both evergreen and deciduous (Bisbal 1989), than any other tropical American cat (Fig. 5). Although it formerly occurred as far north as Texas, it was restricted to riverine forest (L. Emmons *in litt.* 1993). It hunts on the boundaries of such gallery forests and may thus be found some distance from forest cover in savannah habitats (Eisenberg 1990). It appears to be less tolerant of human settlement and altered habitat than its close relatives, the ocelot and oncilla, although it has been occasionally reported outside forested areas (Vaughan 1983, Tello 1986b), such as in shady cocoa or coffee plantations in Venezuela (Mondolfi 1986). In a successional forest mosaic in Belize, one sub-adult male margay spent significantly more time in late secondary growth forest than in other habitat patches, but would make 2-3 day forays into early secondary growth forest (Konecny 1989). Johns (1986) reports, however, that the margay is absent from logged areas. The margay is rarely found at elevations above 1,200 m (Eisenberg 1990).

Population Status

Global: Category 4. Regional: Category 3. IUCN: Insufficiently Known. Very little is known of the margay's status and abundance across its range. The Amazon Basin is its stronghold. It is reported to be rare in northwestern Argentina (Mares *et al.* 1981, A. Canedi *in litt.* 1993) and Uruguay (A. Ximénez *in litt.* 1990). A sub-adult male in successional forest in Belize's Cockscomb Basin Wildlife Sanctuary—where margays appear to be less common than in primary forest—had a home range of 11 km^2 (Konecny 1989). An adult radio-collared male in Brazil's Iguaçu National Park monitored over 18 months by P. Crawshaw (pers. comm. 1993) maintained a home range of 16 km^2.

Protection Status

Upgraded to CITES Appendix I in 1989. National legislation: fully protected over most of its range. Hunting prohibited: Argentina, Brazil, Bolivia, Brazil, Colombia, Costa Rica, French Guiana, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Suriname, Uruguay, Venezuela. No legal protection: Ecuador, Guyana, El Salvador (Fuller *et al.* 1987).

Principal Threats

The margay has been one of the most heavily exploited Latin American cats, with an average annual net trade reported to CITES of 13,934 skins between 1976 and 1984 (Broad 1987). Trade statistics probably do not reflect the actual number of margays killed, as margays began to appear in international trade at a time of concern over the level of exploitation of the ocelot, and species of spotted cats in trade were rarely verified. Illegal hunting for domestic markets or for the underground skin trade has been reported to be a continuing a problem in some areas (Melquist 1984, Paz y Miño 1988, Walton 1991). Aranda (1991) reported that the margay's pelt was the most common in the skin trade in the southern Mexican state of Chiapas, despite its protected status. A margay skin sold for U.S. $5-10, while an ocelot pelt could fetch U.S. $50-90. However, deforestation is now the primary threat to reduced populations now that international trade has virtually ceased.

Action Planning

Projects 96 and 97.

Figure 5. Distribution of the margay (*L. wiedi*).
1. Montes Azules II*; 2. Calakmul V* (Mexico); 3. Tikal II** (Guatemala); 4. Cockscomb Basin IV (Belize); 5. Río Platano II* (Honduras); 6. Santa Rosa II complex (Costa Rica); 7. La Amistad II* (Costa Rica and Panama); 8. Guatopo II; 9. Perijá II (Venezuela); 10. El Cocuy II complex; 11. Amacayacú II (Colombia); 12. Cerros de Amotape II complex; 13. Pacaya Samiria IV; 14. Manú II# (Peru); 15. Manuripi Heath IV complex; 16. Noel Kempff Mercado II (Bolivia); 17. Baritú II (Argentina); 18. Quebrada de Los Cuervos reserve (proposed); 19. Santa Teresa V (Uruguay); 20. Iguaçu II** (Brazil) + Iguazú II** (Argentina) complex; 21. Caparao II; 22. Amazonia (Tapajos) II complex (Brazil).

Canada lynx, *Lynx canadensis* Kerr, 1792

Other Names

Lynx du Canada (French); Kanadaluchs (German); lince del Canada (Spanish).

Description and Behavior (Plate 6)

The Canada lynx has a flared facial ruff, black ear tufts, and long hind legs which lend a slightly stooped posture. The pelage is reddish-brown to grey; the hairs are tipped with white which gives the fur a frosted appearance. There is a rare pallid color phase which suggests partial albinism, known as the blue lynx in the fur trade (Quinn and Parker 1987). The Canada lynx's large spreading feet act like snowshoes, and are twice as effective at supporting its weight on snow as those of the bobcat (Parker *et al.* 1983).

The lynxes show remarkable similarity of appearance compared to other related groups of cats, and the Canada lynx is often treated as conspecific with the Eurasian lynx (Kurtén and Rausch 1959, Tumlison 1987). However, the Canada lynx is only half the size of the Eurasian lynx: average adult weight of Canada lynx males is 10.7 kg (n=201) and females 8.9 kg (n=183) (U. Breitenmoser and C. Breitenmoser-Würsten in prep.). While the Canada lynx is probably a descendent of a Eurasian lynx ancestor which migrated into North America during one of the last two major glacial periods (Werdelin 1981, 1983b), the Breitenmosers (in prep.) argue convincingly that the two should be considered separate species, as they now show marked adaptive differences for prey capture. Whereas the larger Eurasian lynx preys mainly on ungulates, the Canada lynx relies almost exclusively on snowshoe hares, and is uniquely adapted, both behaviorally and physiologically, to exploit a cyclic prey base.

Among felid predator-prey relationships, there are none as closely tied as that between the hare and the Canada lynx (Van Zyll de Jong 1966, Nellis *et al.* 1972, Brand and Keith 1979, Parker *et al.* 1983, Ward and Krebs 1985). The lynx-hare cycle was first discovered from harvest records of the Hudson's Bay Company dating back to the 1800s (Elton and Nicholson 1942: Fig. 6). Numbers of snowshoe hares peak approximately every ten years, and lynx numbers follow the same pattern with a short lag, typically one to two years (Keith 1963, Bulmer 1974). While the populations of many prey and predator species are cyclic and roughly synchronous in the northern latitudes, the snowshoe hare and lynx correlation is particularly close (Keith 1963, Mallory 1987: Fig. 7). The amplitude of the lynx population cycle is greater than that of any other predator (Bulmer 1974), and lynx density during cyclic highs and lows can differ by up to 15-fold (Breitenmoser *et al.* 1993b). As hares decline, fewer lynx

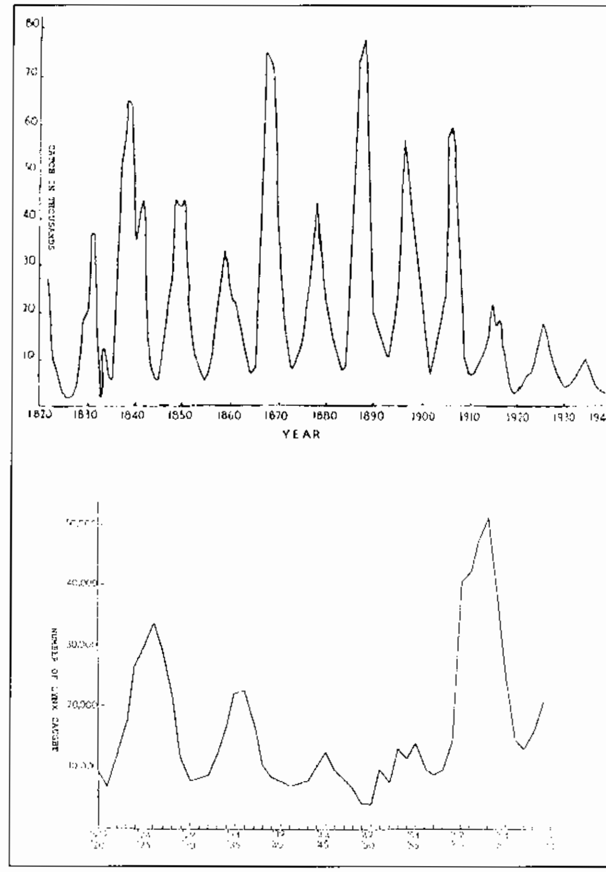

Figure 6. The 10-year cycle in Canada lynx populations visible in annual records of lynx pelt purchases by the Hudson Bay Company, Canada. Source: van Zyll de Jong (1971).

breed, producing smaller litters with few, if any, surviving kits. As hares increase, so do lynx reproduction and recruitment rates (Nellis *et al.* 1972, Brand and Keith 1979, Parker *et al.* 1983, O'Connor 1984, Slough and Ward 1990, Breitenmoser *et al.* 1993b, Mowat 1993). In captivity, female lynx do not show such an early onset of sexual maturity or such high litter sizes as during hare peaks in the wild (Breitenmoser *et al.* 1993b). While lynx will switch prey during periods when hares are scarce (Brand *et al.* 1976), turning to small rodents, ground birds and, exceptionally, ungulates such as white-tailed deer, caribou, and Dall sheep (Saunders 1963, Bergerud 1983, Stephenson *et al.* 1991), lynx populations only reach high densities when supported by snowshoe hares (Brand and Keith 1979, Mech 1980, Ward and Krebs 1985).

There are several competing hypotheses to explain the hare cycle. The most widely accepted explanation is that winter food shortage (Keith 1974) depresses hare reproduction (Carey and Keith 1979) at the population peak and starts the cyclic downturn, and hare numbers are subsequently further reduced due to predation (Keith *et al.* 1984, Boutin *et al.* 1986). Gilpin (1973) and Schaffer (1984) modelled harvest data mathematically, and concluded that the cycle is more complex than a simple predator-prey interaction, involving at least a third additional factor. Another suggested influence involves changes in the nutritional quality of vegetation in response to hare browsing (Bryant 1981, Sinclair and Smith 1984, Bryant *et al.* 1985). Nevertheless, in some areas, hares have declined even when food resources appear sufficient (Keith *et al.* 1984, Krebs *et al.* 1986). Preliminary results achieved from long-term field experiments (Krebs *et al.* 1992) now favor the hypothesis that predation alone, by a variety of specialist and generalist carnivores, is the driving force behind the cycle, as has been suggested for microtine rodents (Hanski *et al.* 1991).

Biology

Birth season: (W) May-June, exceptionally July (Saunders 1961, Nava 1970, Nellis *et al.* 1972, Mowat 1993).

Estrus: no published information on duration or length of cycle (G. Mowat *et al. in litt.* 1993). It is possible that ovulation in the Canada lynx may be at least partly spontaneous, although this is controversial (Van Zyll de Jong 1963, Quinn and Parker 1987, G. Mowat *et al. in litt.* 1993). Lynx may be induced ovulators when prey density is low and there is less chance of meeting a mate, and spontaneous ovulators when prey density is high, improving prospects for breeding and raising young (Kitchener 1991).

Gestation: (W) 63 to 70 days (Saunders 1961).

Litter size: (W) higher (average 3.8-5.3) when prey is abundant, and reduced (2.3-3.5) when prey is scarce (Brand and Keith 1979, Slough and Ward 1990, Mowat 1993); range 1-8 (Tumlison 1987, Breitenmoser *et al.* 1993b). Yearling lynxes give birth to smaller litters (0-4.2: Mowat 1993)

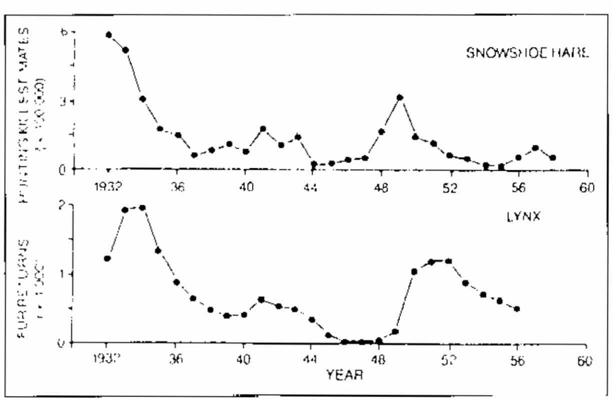

Figure 7. The relationship between snowshoe hare and Canada lynx, showing the lag between the two population cycles. Source: Keith (1963), from Mallory (1987).

Age at independence: (W) generally around 10 months: kits typically leave their mother's range in March-April (Saunders 1961, Bailey *et al.* 1986, Slough and Ward 1990, Mowat 1993).

Age at first reproduction: (W) 10 months (first winter) when prey is abundant, more generally 22-23 months (second winter) (females); second year (males) (Saunders 1961, Van Zyll de Jong 1963, Stewart 1973, Nava 1970, Brand and Keith 1979, O'Connor 1984).

Reproductive rates: (W) up to 100% during hare peaks, and as low as zero during cyclic lows (Mowat 1993).

Interbirth interval: (W) generally one year, rarely two (Tumlison 1987).

Recruitment rates: (W) 60-80% when hares are abundant and increasing, and approaching zero during lows (Brand *et al.* 1976, Brand and Keith 1979, Parker *et al.* 1983, Mowat 1993, Poole 1994). Koehler (1990a) found low recruitment rates of around 12% from 1980-1987 in mature forest in north-central Washington (sub-optimal habitat at the southern edge of lynx range).

Mortality rates: (W) adult mortality rates average 55% for exploited populations in Canada (R. Ward in prep. cited in Slough and Ward 1990). Rates vary dramatically with the hare cycle. Poole (1994) estimated survival rates in an unharvested population to be 90% before and during the decline in hare densities; 25% during the first year of low hare densities; and 37% during the second year of the low. All radio-collared lynx resident prior to or during the hare decline dispersed and/or died by the end of the first winter of low hare densities.

Longevity: (W) up to 15 years (Nava 1970; K. Poole, B. Slough unpubl. data).

Habitat and Distribution

Lynx are distributed throughout the broad boreal forest belt of North America (Banfield 1974) and south into the American Rocky Mountains (Koehler 1990b), with a total range of some 7.7 million km^2 (Parker and Quinn 1987: Fig. 8). The historic range is largely intact, although it has shrunk in the south due to human settlement and forest clearance (Banfield 1974, Quinn and Parker 1987). Lynx will inhabit farming country, but only if it is interrupted by sufficient areas of woodland (Todd 1985). Bobcats appear to be expanding northwards, and have displaced lynx in some areas (Parker and Smith 1983, Rolley 1987). Lynx will travel long distances during both phases of the hare cycle seeking out patches of hare abundance (Ward and Krebs 1985), with movements of up to 1,200 km recorded (K. Poole, B. Slough & G. Mowat, unpubl.

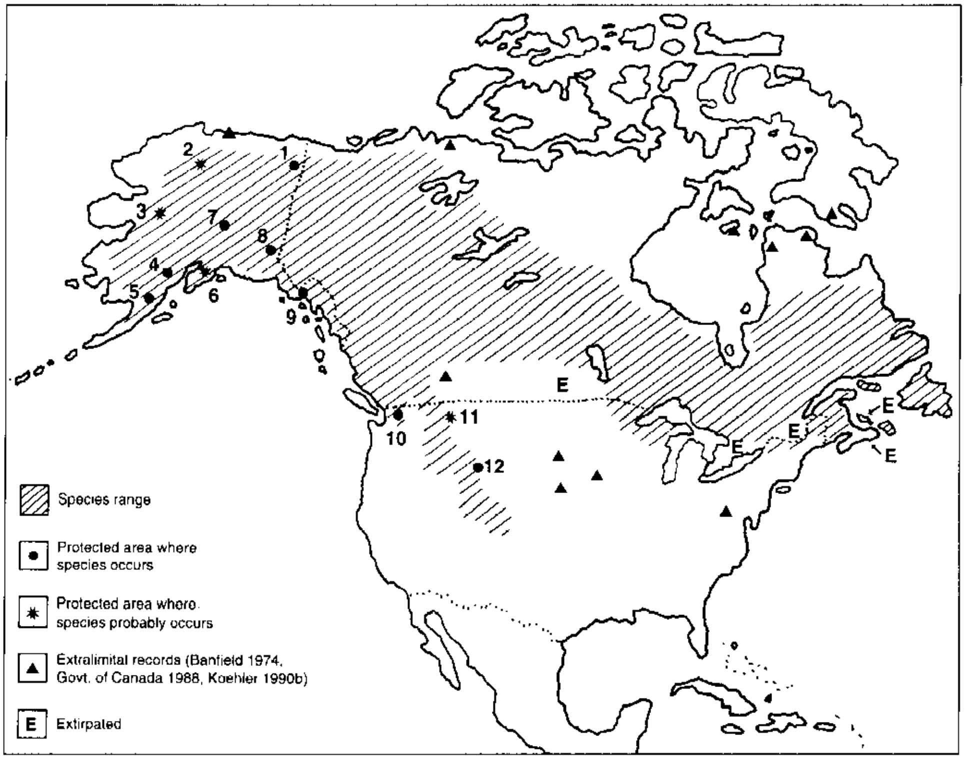

Figure 8. Distribution of the Canada lynx (*L. canadensis*). 1. Arctic IV complex; 2. Noatak II* complex; 3. Innoko IV; 4. Lake Clark II; 5. Katmai II; 6. Kenai IV complex; 7. Denali II*; 8. Wrangell-Saint Elias II; 9. Glacier Bay II; 10. North Cascades II complex; 11. Glacier II*; 12. Yellowstone II# complex (U.S.).

data). Extralimital records have documented lynx in the northern tundra and Arctic islands (Banfield 1974, Govt. of Canada 1988), and in Iowa, South Dakota, Nebraska, and West Virgina (Koehler 1990b). Snowshoe hares prefer new growth vegetation, such as after forest fire or logging, and lynx may cluster in these areas (Quinn and Parker 1987).

Population Status

Global: Category 4. Regional: Category 3. IUCN: not listed. The status of the lynx is generally satisfactory (Quinn and Parker 1987, Govt. of Canada 1988). In Canada, it is considered endangered only in New Brunswick, and has been extirpated from Prince Edward Island and mainland Nova Scotia. The largest populations are found in southern Quebec, northern Alberta, northern British Columbia, Yukon, the Northwest Territories and Alaska (Govt. of Canada 1988; K. Poole, B. Slough *in litt.* 1993). There is some concern that trapping pressure during the 1970s-1980s may have reduced population levels (see Part II Chapter 4), but R. Eagan (pers. comm.) draws attention to low hare cycles since the early 1970s.

The main U.S. lynx population is found in Alaska. Elsewhere, they are more sparsely distributed, occurring in low numbers in the states of Washington, Montana, Idaho, Wyoming, Colorado, Minnesota, Wisconsin, Michigan, New York (reintroduced), Vermont, New Hampshire, and Maine, with the largest populations in the Rocky Mountains. Washington State recently listed the lynx as Threatened, and will take more active measures to aid population recovery (Anon. 1994b). Much of the lynx's American range consists of National Forest lands (Koehler 1990b).

Lynx density fluctuates dramatically with the hare cycle (Breitenmoser *et al.* 1993b). An ongoing long-term study of an unexploited population in good quality habitat in the Yukon found densities of 2.8 individuals (including kittens) per 100 km^2 during the hare low, and 37.2 per 100 km^2 during the peak (G. Mowat and B. Slough, unpubl. data). Poole (1994) obtained very similar figures for his study area in the Northwest Terrritories: 30 lynx per 100 km^2 at the peak, and around 3/100 km^2 the winter following the hare crash. In the south of their range, where snowshoe hare populations appear to be non-cyclic and stable at low densities, Koehler (1990a) reported lynx density at 2.6 individuals per 100 km^2 (north-central Washington). The study was conducted in mature coniferous forest where fires had been suppressed, and the early successional growth preferred by snowshoe hares was limited to isolated pockets.

Home range sizes for lynx range from 4-25 km^2 for females, and 4-70 km^2 for males (G. Mowat and B. Slough, unpubl. data). On the Kenai peninsula, Alaska, Kesterson (1988) found larger home ranges—107 km^2 for females and 225 km^2 for males—but seasonal ranges were smaller, with females only 9.4 km^2 in summer. Male ranges usually encompass those of females (Saunders 1963, Berrie 1973, Parker *et al.* 1983, Ward and Krebs 1985, Kesterson 1988, Slough and Ward 1990), but same-sex overlap has also been found (Berrie 1973, Mech 1980, Carbyn and Patriquin 1983, Noiseux and Doucet 1987; G. Mowat, B. Slough and K. Poole unpubl. data). Breitenmoser *et al.* (1993b) suggest that same-sex overlap reflects a high degree of tolerance of independent offspring by resident lynx, another unusual adaptation of the Canada lynx to a predictably cyclic prey base.

Protection Status

CITES Appendix II. National legislation: managed for exploitation over most of its range. In Canada, trapping is regulated through closed seasons, quotas, limited entry and long-term trapping concessions. (See Part II Chapter 4 for a more detailed discussion of harvest management.) In the United States, trapping is permitted only in Alaska, Idaho, and Montana (Koehler 1990b).

Principal Threats

In general, the future of the lynx looks more promising than for many other felids. However, there is still cause for concern, as harvests of Canada lynx during the cyclic low periods have progressively fallen since the mid-1970s, and hare numbers have similarly been lower since these periods (Todd 1985, Govt. of Canada 1988, R. Eagan, pers. comm.).

Lynx are easily trapped in comparison to other furbearers (Quinn and Parker 1987). At the low point of the hare cycle, lynx may become more vulnerable to exploitation as they disperse in search of food—travelling greater distances can increase the chances of being caught in a trap. Recruitment is also falling during this phase of the cycle, and it is possible that trapping pressure could reduce numbers to the extent that recovery to previous levels is not attained when hares again increase (Brand and Keith 1979, Parker *et al.* 1983, Bailey *et al.* 1986).

Several management options have been recommended to prevent over-trapping, including prohibiting exploitation in hare refugia (small patches of optimal habitat) throughout the cycle (Slough and Ward 1990, Poole 1992). In the past when lynx pelt prices were high (U.S. $685 in 1981), trappers would seek out these refugia and concentrate their trapping efforts there (Carbyn and Patriquin 1983). Brand and Keith (1979) recommended that harvests be completely suspended for the 3-4 year low of the hare cycle, so that potentially more lynx are available for harvesting in peak years. Bailey *et al.* (1986) recommended a combination of harvest suspensions in the more accessible trapping areas during low hare years, and a quota system as lynx numbers increase.

Government authorities have either implemented these recommendations or initiated harvest impact research programs, as discussed in Part II, Chapter 4. In addition, trapping methods may change as a result of pressure from the European Union for countries to ban the use of the leghold trap and adopt internationally accepted humane trapping standards (see the bobcat Species Account).

Quinn and Parker (1987) do not believe that habitat alteration has had significant impact on lynx populations, although in the southern portions of its range optimal habitat for snowshoe hares is more patchily distributed (Wolff 1980, Sievert and Keith 1985). Modified logging, leaving interspersing areas of good tree cover, can actually benefit both lynx and their prey (Koehler and Brittell 1990). However, suppression of forest fires limits early successional growth favored by hares (Fox 1978), and may ultimately reduce hare abundance (B. Slough *in litt.* 1993).

Action Planning

Project 98.

Geoffroy's cat, *Oncifelis geoffroyi* (d'Orbigny and Gervais, 1844)

Other Names

Chat de Geoffroy (French); Geoffroykatze, Kleinfleckkatze, Salzkatze (German); gato de mato, gato montés, gato de las salinas (Spanish); gato montés comun (Argentina); gato do mato pelo curto, gato do mato de Geoffroy (Brazil); gato montés argentino (Chile).

Description and Behavior (Plate 6)

Geoffroy's cats are small cats, uniformly patterned with small black spots of nearly equal size and spacing. Coat color tends to ochraceous in the north of its range and grey in the south (Guggisberg 1975, Ximénez 1975). Melanism is fairly common (Cabrera and Yepes 1960, Foreman 1988, Brooks 1992). Adult males in Patagonia weighed an average of 4.8 kg (n=5), and females 4.2 kg (n=2) (Johnson and Franklin 1991). Geoffroy's cats have been described as good swimmers that readily enter water (Weigel 1975). In southern Chile's Torres del Paine National Park, one female was known to have crossed a 30 meter wide fast-flowing river at least 20 times (Johnson and Franklin 1991). Fish (*Characidae*) were found in an examination of stomach contents in Uruguay, in addition to amphibians, reptiles, birds, and small mammals (A. Ximénez *in litt.* 1990). Geoffroy's cats are also described as primarily nocturnal and partially arboreal (Cabrera and Yepes 1960). In the first radiotelemetry study of the species, Johnson and Franklin (1991) confirmed this description: Geoffroy's cats rested during the daytime either in dense ground vegetation or in tree cavities. Of 325 scats located by the researchers, 93% were in arboreal middens in the crooks of trees. The diet consisted primarily of rodents and European hares. Hares were selected especially during the spring and summer birth season when juveniles were abundant. Geoffroy's cats were twice seen carrying European hare carcasses into a tree.

Biology

Birth season: (W) December-May (Ximénez 1975, Johnson and Franklin 1991, Brooks 1992).

Estrus: (C) 2.5 ± 0.5 days (n=2).

Estrus cycle: (C) 20 days (n=1: Mellen 1989).

Gestation: (C) 72-78 days (Green 1991).

Litter size: (C) 2.31 ± 0.13 (n=14) (Mellen 1989).

Age at sexual maturity: (C) 18 months (females), 24 months (males) (Foreman 1988), but as early as 9-12 months (P. Quillen *in litt.* 1993).

Interbirth interval: (W) reportedly one litter per year (Cabrera and Yepes 1960).

Longevity: (C) up to over 14 years (P. Quillen *in litt.* 1993).

Habitat and Distribution

Geoffroy's cat has been described as occurring in a wide variety of habitat types (Koford 1976, Melquist 1984, Broad 1987). It is distributed throughout the pampas grasslands and arid Chaco shrub and woodlands, and up around the Salinas Grandes (alpine saline desert of northwestern Argentina) to 3,300 m in the Andes (Cabrera and Yepes 1960, Ximénez 1975, Brooks 1992). However, it is not found in either the tropical rain forests or southern broad-leaved forests, and avoids open areas, preferring dense, scrubby vegetation (Burmeister 1879, Johnson and Franklin 1991). Therefore, throughout the broad stretches of Southern Cone grassland, it is restricted to forest patches or riparian vegetation (Cabrera and Yepes 1960, Ximénez 1975). It is sympatric throughout its range with the pampas cat, and the preference of Geoffroy's cat for dense ground cover may serve to separate the two species ecologically (Fig. 9).

Population Status

Global: Category 4. Regional: Category 3. IUCN: not listed. Throughout its range, Geoffroy's cat has been described as the most common of the small cats (Ximénez 1973, Melquist 1984, Brooks 1992), with the exception of southern Chile, where it is restricted to a small area of cold scrublands east of the Andes (Glade 1988). However, there are fears that a decade of high-volume skin trade has severely reduced populations (Govt. of Brazil 1992). Its status is not well known.

In Torres del Paine National Park, female annual home ranges averaged 3.7 ± 1.1 km^2 (n=2), and males 9.2 ± 1.7 km^2 (n=5). Female ranges overlapped, while males apparently did not. Density was estimated at 1.2 individuals per 10 km^2 (including kittens) in prime habitat *(Notho-*

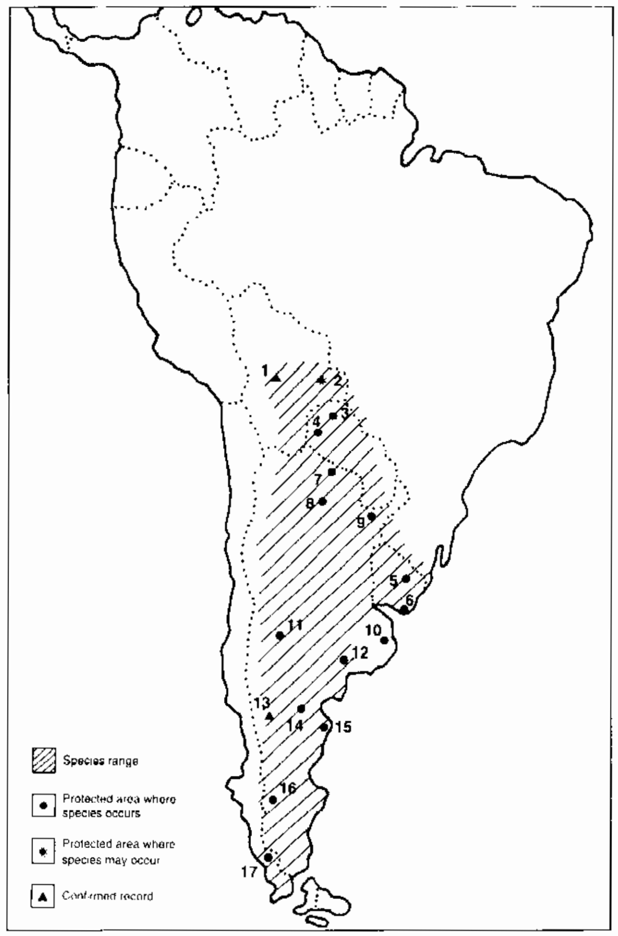

Figure 9. Distribution of Geoffroy's cat (*O. geoffroyi*).
1. Specimen taken near Tiraque (Cabrera 1957); 2. Río Boppi VI (Bolivia); 3. Defensores del Chaco II; 4. Teniente Encisco II (Paraguay); 5. Quebrada de los Cuervos reserve (proposed); 6. Laguna de Castillos IV complex (Uruguay); 7. Río Pilcomayo II; 8. Fuerte Esperanza I; 9. Iber IV complex; 10. Campos del Tuyú I complex; 11. El Payén I; 12. Sierra de la Ventana II; 13. Specimen taken just east of Bariloche, possible occurrence in Nahuel Huapi II complex (Melquist 1985, O.N. Herrera *in litt.* 1992); 14. Meseta de Somuncura VIII; 15. Península de Valdés VIII; 16. Perito Moreno IV (Argentina); 17. Torres del Paine II* complex (Chile).

fagus beech forest and matorral shrubland), and at 0.7 per 10 km^2 over the entire shrub/grassland mosaic found in the park (Johnson *et al.* in press).

Protection Status

Upgraded to CITES Appendix I in 1992. National legislation: fully protected across its range. Hunting prohibited: Argentina, Bolivia, Brazil, Chile, Paraguay, Uruguay. Domestic trade prohibited by all range states (Fuller *et al.* 1987, Govt. of Brazil).

Principal Threats

The species has been exploited commercially since the international cat skin trade boomed in the late 1960s, with nearly 350,000 skins exported from Argentina alone between 1976 and 1979 (Mares and Ojeda 1984). Trade volumes remained high into the 1980s as trade in ocelot pelts declined, averaging 55,000 per year between 1980-1984 (Broad 1987). Paraguay and Bolivia were the main exporters (in contravention of national legislation) during this time, although it is believed that the bulk of these skins were smuggled in from Brazil and Argentina. International trade has since declined—no significant trade has been reported since 1988 (Govt. of Brazil 1992, WCMC unpubl. data). Paraguay and Uruguay remain as important domestic markets for pelts (Brooks 1992, Ximénez *in litt.* 1990). However, Walton (1991) reports that most pelts in trade today are derived from cats killed as pests and livestock predators, and that commercial hunting as it existed in the past has essentially ceased.

Geoffroy's cats appear to tolerate moderate levels of deforestation (Koford 1973, Brooks 1992). So little is known about the species' ecological requirements that it is at present impossible to judge the actual impact of hunting or habitat loss.

Action Planning

Project 99.

Puma, *Puma concolor* (Linnaeus, 1771)

Other Names

Cougar, mountain lion, catamount, panther (English); puma (French); Puma, Silberlöwe (German); léon, léon colorado, léon de montaña (Spanish); onça vermelha, onça parda suçuarana (Brazil); léon sabanero (Colombia); tig rouge (French Guiana); guasura, yagu-pyt (Guarani); cabcoh (Mayan); leopardo (Mexico); reditigri (Suriname).

Description and Behavior (Plate 4)

The puma is an exceptionally successful generalist predator, and its adaptability probably helped it survive the late Pleistocene extinctions of the other large North American felids. Although it is a big cat, it is believed to be more closely related to the small cats, lacking the elastic hyoid and enlarged vocal folds of the Pantherines (Hast 1989). While it cannot roar, it is capable of a variety of vocalizations, and both sexes have a distinctive call, likened to a woman's scream, which is probably associated with courtship (Young and Goldman 1946). Average weights range from 53-72 kg for adult males and 34-48 kg for adult females (Anderson 1983, Pall *et al.* 1988), and males have exceptionally weighed up to 120 kg (Banfield 1974). Pumas tend to be larger away from the equator toward the poles (McNab 1971, Kurtén 1973, Iriarte *et al.* 1990). They have large feet and proportionally the longest hind legs of the cat family (Gonyea 1976). The coat is plain (hence the Latin name *concolor*), which can vary in color from silvery-grey to tawny to reddish; as with the jaguarundi, coat color can be very different even between siblings (P. Crawshaw, pers. comm.). Faint horizontal stripes may occur on the upper forelegs (P. Jackson, pers. comm.). Melanism has been widely reported, and albinism infrequently (Guggisberg 1975, Tinsley 1987, Anon. 1989b). Young kittens are spotted, with blue eyes.

The known prey of pumas ranges from insects, birds, and mice up to porcupine, capybara, pronghorn, wapiti, bighorn sheep, and moose (reviewed by Guggisberg 1975, Anderson 1983, Lindzey 1987, Iriarte *et al.* 1990, Hansen 1992). Large ungulates, particularly deer, are the puma's principal prey in North America. Studies conducted in the region have found that ungulates make up an average of 68% of the diet (Iriarte *et al.* 1990). Ackerman *et al.* (1986) suggest that the energy requirements of females with young are such that viable populations cannot exist in areas devoid of deer-size ungulates. For example, they predicted that a resident female (based on studies in southern Utah) would kill a white-tailed deer every 16 days, and that the interval would shrink to nine days when her kittens were three months old, and to three days when the kittens were nearly mature at 15 months.

However, in the southern parts of puma range, and particularly in the tropics, small to medium-sized prey appear to be more important. Although the studies on which this conclusion is based suffer from extremely small sample sizes (Rabinowitz and Nottingham 1986, Emmons 1987, Crawshaw and Quigley in prep.), Iriarte *et al.* (1990) suggest that the puma's smaller body size in the tropics, and its low rate of predation on larger prey (such as tapirs), are linked to interspecific competition with the jaguar (the largest American felid). Pumas in the tropics are probably still capable of taking large prey, but Crawshaw and Quigley (in prep.), working on a ranch in the subtropical Brazilian Pantanal, found that while pumas take calves of domestic cattle and sheep, adult cattle were taken only by jaguars. Still, even in Chile, where jaguars do not occur, small prey is a key element of puma diet. Pumas in the mountains of southern Chile eat 25 European hares for every one guanaco (Johnson *et al.* in press). Iriarte *et al.* (1991) point out that the European hare was introduced to South America only 90 years ago, and its significance as a prey item for pumas demonstrates the flexibility of their predatory behavior. It is interesting that the puma occurs in a variety of habitats and takes both large and small prey, similarly to the leopard in the Old World, while the jaguar, like the tiger, is closely tied to well-watered forested environments and is capable of taking very large prey.

Radiotelemetry studies in North America and southern Chile have found pumas to be primarily nocturnal and crepuscular, with activity peaks at dusk and dawn, and limited diurnal activity (Van Dyke *et al.* 1986a, review by Hansen 1992, Johnson *et al.* in press). Males make scrapes in prominent locations, and especially along boundaries of home ranges. This behavior apparently advertises temporal presence (Hornocker 1969, Seidensticker *et al.* 1973). Large kills are often covered with scraped-over vegetation and dirt, and pumas often remain in the vicinity, returning frequently to feed. Seidensticker *et al.* (1973) found that, in the winter, one puma fed from a carcass for 19 days. However, pumas rarely feed from carcasses of animals which they themselves have not killed (F. Lindzey *in litt.* 1993).

Biology

Reproductive season: (W) Probably year-round (Sweanor and Logan 1992, Ross and Jalkotzy 1992), although most births are reported to occur in the warmer months of April-September in the north of their range (Robinette *et al.* 1961, Eaton and Verlander 1977, Ashman *et al.* 1983, Lindzey 1987). In the Torres del Paine National Park in southern Chile, all known births (n=4) took place between February-June (Johnson *et al.* in press).

Estrus: (C) 8 days.

Estrus cycle: (C) 23 days (Hansen 1992).

Gestation: (C & W) 91.9 ± 4 days.

Litter size: (C & W) average 2.2-2.7 (Anderson 1983, Currier 1983, Ross and Jalkotzy 1992); range 1-6; possibly only single kitten first litter (Lindzey 1987).

Cub survival: (W) Hemker *et al.* (1986) estimated survival of cubs to dispersal at 67% in a non-hunted population in southern Utah, and suggested that cub survival would be less in hunted populations, particularly if hunting seasons coincided with seasonal birth peaks. However, Ross and Jalkotzy (1992) found 97% cub survival in a hunted population.

Age at independence: (W) 12-18 months (Anderson 1983).

Age at sexual maturity: (W) both sexes 24 months, and females sometimes as early as 20 months (Lindzey 1987, F. Lindzey unpubl. data), but time of first breeding probably depends on when a female is able to establish her territory (Hornocker 1970, Seidensticker *et al.* 1973). Logan *et al.* (1986) found that females only entered the breeding population at age 3-4 years in their hunted study population in Wyoming. Females in stable populations rarely breed with more than one male during estrus (Hemker 1982).

Recruitment rates: (W) 1.0-1.3 kittens per breeding female (Alberta: Jalkotzy *et al.* 1992).

Interbirth interval: (W) can be one year (Robinette *et al.* 1961), but more generally 18-24 months (Lindzey 1987).

Adult sex ratio: (W) most studies report 2:1 female:male ratio of breeding adults, although other ratios, both higher and lower, have been found (reviewed by Beier 1993).

Adult mortality rates: (W) Natural mortality appears to be low, on the order of <5% (Hornocker 1970, Currier *et al.* 1977, Ashman *et al.* 1983, Murphy 1983, Logan *et al.* 1986). Mortality caused by sport hunting can be high, particularly among adult and sub-adult males. Sport hunting in Alberta accounted for 63% of known mortality of radio-collared pumas (n=10 of 16) from 1981-1989, and 100% of sub-adult males (n=5) (Ross and Jalkotzy 1992). Mortality caused by intraspecific conflict may be higher in both populations which are hunted, where immigrants compete to establish territories (Logan *et al.* 1986), and in populations where food resources are relatively scarce, such as semi-arid desert in New Mexico (Hornocker 1992, Sweanor and Logan 1992).

Longevity: (W) probably 8-10 (Hansen 1992), but up to 12-13 years (Currier 1983), and a female puma on Canada's Vancouver island was killed by hunters when she was at least 18 years old (M. Jalkotzy *in litt.* 1993); (C) up to 21 years (Hansen 1992).

Habitat and Distribution

Pumas have a very broad latitudinal range encompassing a diverse array of habitats (Fig. 10), from arid desert to tropical rain forest to cold coniferous forest, from sea level up to 5,800 m in the Andes (Redford and Eisenberg 1992). While several studies have shown that habitat with dense understory vegetation is preferred (Seidensticker *et al.* 1973, Logan and Irwin 1985, Laing 1988, Johnson *et al.* in press), pumas can live in very open habitats with only a minimum of vegetative cover (Lindzey 1987, Seidensticker 1991b). Pumas are occasionally reported from areas of intensive agricultural cultivation, although such

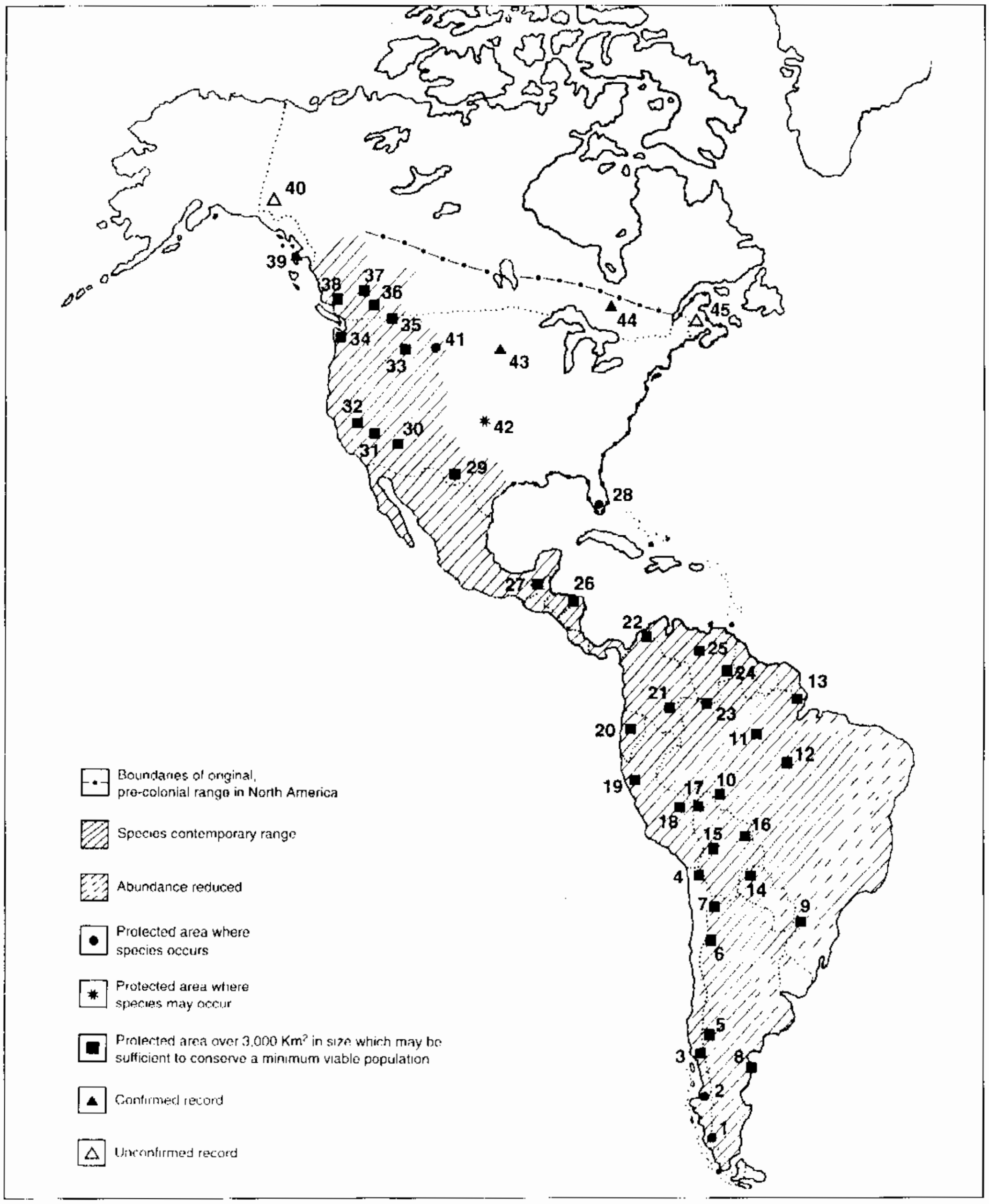

Figure 10. Past and present distribution of the puma (*P. concolor*). 1. Los Glaciares II** (Argentina) + Torres del Paine II* (Chile) complex; 2. Laguna San Rafael II* complex; 3. Vicente Perez Rosales II complex; 4. Lauca II* complex (Chile); 5. Los Alerces II, Lanín II + Nahuel Huapi II complex; 6. San Guillermo IV* complex; 7. Los Andes I; 8. Península de Valdés VIII (Argentina); 9. Iguazú II** (Argentina) + Iguaçu II** (Brazil) complex; 10. Pacaas Novos II complex; 11. Amazonia II complex; 12. Araguaia II complex; 13. Lago Piratuba I (Brazil); 14. Defensores del Chaco II (Paraguay); 15. Isiboro Sécure II; 16. Noel Kempff Mercado II; 17. Manuripi Heath IV complex (Bolivia); 18. Manú II#; 19. Huascarn II# (Peru); 20. Ecuador parks: Sangay II**, Cayambe-Coca I, and Yasuní II complex; 21. Chiribiquete II; 22. Sierra Nevada de Santa Marta II* complex (Colombia); 23. Serranía de la Neblina II (Venezuela) + Pico da Neblina II (Brazil) complex; 24. Canaima II; 25. Aguaro-Guariquito II (Venezuela); 26. Río Platano II* (Honduras); 27. Calakmul V* (Mexico) + Maya IX* (Guatemala) complex; 28. Big Cypress II; 29. Big Bend II*; 30. Grand Canyon II** complex; 31. Death Valley III; 32. Yosemite II** complex; 33. Yellowstone II# complex; 34. Olympic II# (U.S.); 35. Glacier II* (U.S.) + Waterton Lakes II (Canada); 36. Jasper II complex; 37. Wells Gray II; 38. Tweedsmuir II; 39. puma shot on Wrangell Island in 1989; 40. puma sightings in the Kluane Lake region (Tischendorf and Henderson 1993) (Canada); 41. Black Hills National Forest/Custer State Park complex; 42. Ozark/Ouachita/Mark Twain National Forest complex; 43. Young male puma captured in 1991 in agricultural region of southwest Minnesota; 44. Puma shot near Lake Abitibi in 1992 (Tischendorf and Henderson 1993); 45 tracks and scat found in east-central New Brunswick (Cumberland 1993).

animals are likely to be transient (Tischendorf and Henderson 1993).

The puma's historical distribution included every major habitat type in the Americas up to the boreal forests of the far north, but pumas have been essentially eliminated from eastern North America. Severe reduction of native ungulate populations through hunting and forest clearance during the nineteenth century, coupled with direct persecution of the puma, are the probable causes (Wright 1959). Deer have since multiplied and spread, and the puma is now found in areas colonized by deer which were outside its historical range, such as the Great Basin Desert in the western U.S. (Berger and Wehausen 1991).

Population Status

Global: Category 5a(A). Regional: Category 4(A). IUCN: eastern cougar (*F.c. cougar*) and Florida panther (*F.c. coryi*; see Box 2) Endangered in North America. In Central and South America, the puma still occurs throughout much of its historical range. However, focused studies have only been carried out in North America.

In Canada, pumas have been extirpated from most of their former range, and the main population is now found in southwestern British Columbia, where they are estimated to number 3,500-5,000 (Hummel 1990). In adjacent habitat in Alberta, Jalkotzy *et al.* (1992) estimated a population of 685 pumas, with 93% living outside national parks. There are occasional reports of pumas in the far south of the Northwest Territories (K. Poole *in litt.* 1993), and in Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, and Nova Scotia (Anon. 1989b). Presence in a remote forested area of east-central New Brunswick was recently confirmed by the finding of a set of tracks and scat (Cumberland 1993). In Manitoba, on the other hand, while puma reports are made to the government at a rate of 10-50 per year (Johnson 1990), the only field survey produced no evidence of puma presence (M. Jalkotzy *in litt.* 1993). An Eastern Panther Recovery Team has been formed by the Canadian Wildlife Service (Tischendorf 1992a).

As in Canada, the puma was essentially eliminated from most of the eastern U.S. within 200 years following European colonization (Wright 1959). The only eastern state where the puma is unequivocally known to persist is Florida (see Box 2). In the northeastern U.S., hundreds of sighting reports have been investigated and compiled (Wright 1972, Anon. 1989b, Tischendorf 1992b), but the existence of actual remnant populations has not been verified. Several networks have been established to further investigate the species status in the region, including the Eastern Puma Research Network and the Friends of the Eastern Panther (Tischendorf 1992a). Pumas are rare in the central plains region, with few resident populations (Tischendorf and Henderson 1993). The puma has fared much better in the less populated western U.S., and with changes in management status from "varmint" (vermin) to game animal, numbers there appear to be increasing (reviewed by Beier 1991, Seidensticker and Lumpkin 1992). Population estimates by state wildlife authorities indicate that pumas in the western U.S. probably number over 10,000 (Tischendorf 1991).

Anderson (1983) summarized information on densities of puma populations in North America. For those populations that were studied for at least 12 months or over two consecutive winters, densities ranged from 0.5 to 4.9 individuals/100 km^2 (studies carried out only in North America). The lowest densities have been reported from arid regions (Hemker *et al.* 1984, Sweanor 1990). A protected population in Patagonia (50° S) was found to have an average density of 7 animals/100 km^2, among the highest densities so far documented, and presumably the result of protection and an abundant prey base (Iriarte *et al.* 1991, Johnson *et al.* in press). Crawshaw and Quigley (unpubl. data) estimated density at 4.4 individuals per 100 km^2 on a cattle ranch in the Brazilian Pantanal. Based on a number of North American studies, Shaw (1989) concludes that adult resident carrying capacity is of the order of 26-52 km^2 per individual. Densities have not been calculated for pumas inhabiting tropical forests.

Lindzey (1987) summarized the results of North American studies of puma home ranges: average range size varied from 32-1,031 km^2. Male home range size tended to be at least several hundred km^2, while most female ranges were less than 100 km^2. Male home ranges typically encompass those of several slightly overlapping resident females; resident male ranges only occasionally overlap. However, one study in central California's Diablo Mountains found that male ranges overlapped while those of females did not (Hopkins 1989). The largest home ranges have been found in arid environments (McBride 1976), while the smallest documented home ranges appear to be in areas where the major prey is non-migratory (Sitton 1977). Pumas living in mountains that receive heavy snowfall tend to shift their ranges downward in elevation, following seasonal movements of ungulates (Seidensticker *et al.* 1973, Ashman *et al.* 1983, Hemker *et al.* 1984).

Protection Status

CITES Appendix II; eastern and Central American subspecies (*F.c.coryi*, *costaricensis*, and *cougar*) Appendix I. National legislation: protected over much of its range. Hunting prohibited: Argentina, Brazil, Bolivia, Chile, Colombia, Costa Rica, French Guiana, Guatemala, Honduras, Nicaragua, Panama, Paraguay, Suriname, Venezuela, Uruguay. Hunting regulated: Canada, Mexico, Peru, United States. No legal protection: Ecuador, El Salvador, Guyana (Fuller *et al.* 1987, R. Hoogesteijn *in litt.* 1993).

There is good information available about the protection status of the puma on a regional level in North America. The eastern cougar is protected in the Canadian provinces of Nova Scotia, New Brunswick, and Ontario (Macey 1979). Elsewhere in Canada, pumas are protected in Manitoba, Saskatchewan, and Yukon, but not at all in the Northwest Territories. Hunting is regulated in Alberta and British Columbia. In the U.S., the eastern cougar is fully protected under the Endangered Species Act. In the west, pumas are fully protected only in South Dakota and California. Hunting is regulated in Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Oklahoma, Oregon, Utah, Washington, and Wyoming. Pumas are not legally protected in Texas (Tischendorf 1991).

In California, which holds one of North America's largest puma populations, voters in 1990 narrowly approved an initiative which directed the state to prohibit sport hunting of pumas (formerly permitted), and to allocate U.S. $30 million a year for the next 30 years toward provision of habitat for pumas and other threatened species (West 1991).

Principal Threats

Across the Americas, ranchers are likely to continue to view pumas as a threat to their livestock and to attempt to elimate them. Pumas are vulnerable because they return to their kills, which can be poisoned, and because they take to trees when hunted by dogs. Shaw (1977) found that calves of less than one year, weighing generally under 90 kg, were most frequently taken in Arizona. Crawshaw and Quigley (in prep.) found similar results on a Brazilian ranch, and Yañez *et al.* (1986) observed that pumas were significant predators of sheep on ranches in Chile. See Part II, Chapter 2 for further discussion of livestock depredation by pumas and ways to control it.

With legal protection, pumas now occur very close to settled areas throughout western North America, and attacks on people, while infrequent compared to other hazards from animals or nature (such as lightning strikes), have increased (Beier 1991). However, there seems to be genuine public support for the puma's presence in most of North America despite the dangers, a major change in public perception over the past few decades (Seidensticker and Lumpkin 1992, Jalkotzy *et al.* 1992).

Action Planning

Project 6 and 100-103.

Box 2
The Florida Panther, *Puma concolor coryi* (Bangs, 1899)

A Worst-Case Scenario

The problems involved when wild cats are reduced to a minimal level and they live in a human-dominated area, are well illustrated by the case of the puma subspecies known as the Florida panther. The threats facing the panther are numerous and complex, and are indicative of the likely fate of big cats around settled areas if preventive conservation measures are not taken. A remarkable, broad-based effort has been mounted to save the Florida panther, and the complexity, difficulties, and costs involved demonstrate the importance of taking action to conserve cat populations before they become seriously threatened.

The Florida panther was formerly found throughout the southeastern United States, but had disappeared from most of its range by the late 1920s (Lowery 1936, Young and Goldman 1946, Tinsley 1970). Florida was one of the first states to offer any legal protection to the panther (in the 1950s), and it is now home to the only known puma population in eastern North America, consisting of just 30-50 adult animals (Jordan 1994) confined to fragmented patches of habitat (Fig. 11).

One sub-population (Everglades National Park) became extinct in 1991, when the last two females known to live in the area died (Hansen 1992)—the Everglades are only occasionally frequented now by one male (D. Jordan, pers. comm. 1994). Everglades' panthers had been previously analyzed genetically and were found not to be pure *coryi:* they carried genes from pumas of partial South American descent released in the Everglades in the late 1950s to early 1960s (O'Brien *et al.* 1990). In comparison with the main Florida panther population (Big Cypress swamp ecosystem), this introgression of new genetic material could be advantageous, as the Big Cypress animals have a number of physiological impairments which can be ascribed to inbreeding depression, caused by population isolation and decline. These include a high (95%) abnormal sperm count among males, cryptorchidism (one or two undescended testicles), heart murmurs, and vaginal fibropapillomas (possibly impeding reproductive success).

Other health problems affecting the population include exposure to domestic animal-borne diseases, such as feline panleukopenia, rabies, feline HIV and parvovirus (genetic homogeneity may

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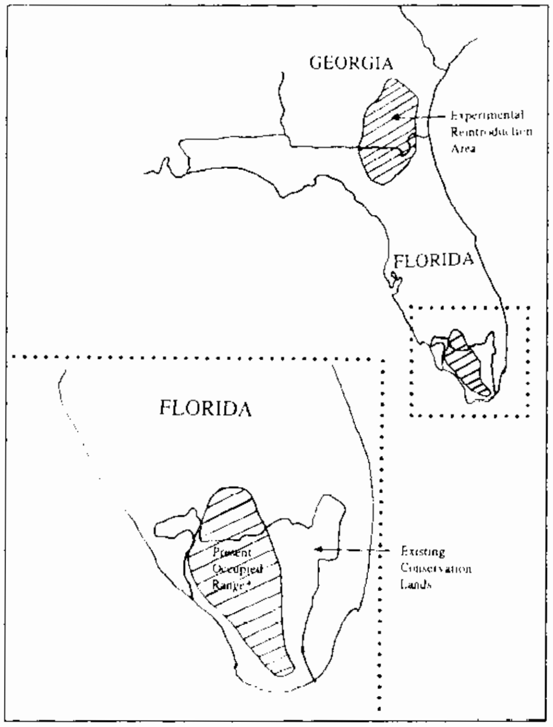


Figure 11. Distribution of the Florida panther (*P. concolor coryi*). Range based on radio-instrumented segment of the population (19 panthers/May 1994). Source: Dennis B. Jordan, Florida Panther Coordinator, U.S. Fish and Wildlife Service.

impede immune response), and events which may be due to poor nutrition, such as anemia and parasitic infestation (Roelke *et al.* 1993). Between 1979-1991, road kills accounted for half of all known panther deaths (11 out of 22: Maehr *et al.* 1991a). Very high levels of mercury were found in two of the dead Everglades panthers, possibly from eating racoons which had eaten contaminated fish (Jordan 1990, Hansen 1992).

These problems have taken on enormous dimensions because little habitat remains to support larger numbers of panthers. What is left of the Florida panther's habitat is fragmented by agriculture and settlements and criss-crossed by roads. Some of the most strategically located forested areas are privately owned, and some owners are hostile to the panther recovery efforts for fear of losing land-use options—such as citrus growing. Of approximately 12,555 km^2 of occupied panther range in south Florida, only 47% is in state and federal ownership (Logan *et al.* 1993). None of the radio-collared panthers has restricted its movements solely to public lands. Moreover, as is the case across much of the world, it is marginal or less productive land that has been given over to the public trust. Studies have shown that panthers that primarily inhabit private lands are in better physical condition and have a higher rate of reproductive success than individuals on public lands, possibly due to greater prey availability and less disturbance from hunters (Maehr 1990).

A population viability analysis conducted by the IUCN/SSC's Captive Breeding Specialist Group concluded that the Florida panther could become extinct within 25-40 years under prevailing demographic and genetic conditions (Seal *et al.* 1989).

There are a number of lessons to be drawn from the case of the Florida panther. The response of the American conservation authorities has been impressive and has involved creative management techniques. Following a private initiative in 1976, a Florida Panther Recovery Team was established with representatives of various Federal and State agencies and other experts and a full-time Florida Panther Coordinator. The first task was to find out if panthers survived and their location. A radio telemetry program was initiated amid public controversy which intensified when a panther died after being darted with a tranquilizer. However, the program continued with official approval. In 1986, a Florida Panther Interagency Committee was established and went on to work with private landowners to develop a program to preserve vital corridors and strategic parcels of habitat, with priority initially allocated to 3,752 km^2 of privately-owned land (Maehr 1990, Logan *et al.* 1993).

However, government response has still been hampered by bureaucracy. A former member of the Panther Advisory Council has documented the difficulties which arose in inter-agency cooperation and declared that problems with the Florida panther program "focus attention on a poorly understood impediment of the recovery of endangered species in the United States: a land management bureaucracy that will not acknowledge the novel demands of small population biology—the requisite discipline" (Alvarez 1993).

The impact of a major highway which cuts through the heart of panther country is being lessened by the construction of fences and 36 underpasses, undertaken at a cost of $30 million (Harpster 1990); panthers have been using the underpasses (Humphrey *et al.* 1991). Emphasis is being given to ensuring adequate densities of white-tailed deer and wild hogs by control of sport hunting and other recreational activities on public lands. Wild panthers have been vaccinated against several diseases. Seven kittens have been removed from the wild and placed in a

Continued on next page

captive-breeding program to build up a reserve population to supplement panthers in the wild (Jordan 1991). The panther has been designated the official Florida state animal. Public support has been remarkably strong, and interest has been generated by the Florida Power and Light Co.'s publication and distribution of a popularized but thorough discussion of the Florida Panther Recovery Plan (USFWS 1987, Van Meter 1988).

The government has set the long-term goal of achieving three viable, self-sustaining populations within the panther's historic range (Jordan 1993). Given the unlikelihood of the current population thriving and expanding, reintroduction is the government's preferred management strategy, and it is currently carrying out its second reintroduction feasibility study. In the first attempt, seven wild-caught Texas panthers were released in the Osceola National Forest, in northern Florida on the boundary with Georgia. While there was evidence of successful land tenure, all were re-captured earlier than planned due to conflicts with humans—one, for example, climbed up a tree in a Jacksonville backyard (Bolgiano 1991). The latest attempt involves 10 Texas panthers—three captive-bred and seven wild-caught adults—which were radio-collared and released in the same area in February 1993 (Belden and McCown 1993: Fig. 11). It is interesting that, after four months of monitoring, the captive-raised panthers (which had been given pre-release training in catching live prey) appeared to have settled down more quickly than the wild-caught cats, using smaller areas and more frequently capturing prey (Belden and McCown 1993). However, the same problems which occurred in the last study are happening again. Three cats (two wild-caught, one captive-raised) have been recaptured, and others (wild-caught) relocated after people complained that the cats threatened life or property (Belden and McCown 1993, Jordan 1994). The re-capture of the captive-raised male occurred after he was seen killing a house cat (D. Jordan, pers. comm. 1994). This provides a good example of the difficulties of reintroducing and conserving big cats near people.

The Florida Panther Interagency Committee is attempting to deal with the genetic problems of the panther by giving conceptual approval to restoring historic gene flow (USFWS 1993), either through eventually facilitating connectivity between the south Florida panthers and reintroduced Texas panthers, or through interactive outbreeding with captive animals. These plans are complicated by the fact that the U.S. Endangered Species Act may not extend protection to progeny resulting from intercross breeding. A policy determination on this matter is presently under development.

Ocelot, *Leopardus pardalis* (Linnaeus, 1758)

Other Names

Ocelot (French); Ozelot (German); tigrillo, ocelote, gato onza (Spanish); tirica (Argentina); gato onza (Argentina, Bolivia, Peru); chivi-guazu (Argentina, Paraguay); cunaguaro (Argentina, Venezuela); tigrezillo, gato bueno (Bolivia); maracaju-acu, gato mourisco, jaguatirica (Brazil); gato maracaja (Brazil, Paraguay); maracaya, maracaja (Colombia); manigordo (Costa Rica, Nicaragua, Panama, Venezuela); chat tig (French Guiana); yagua-tirica (Guarani); zac-xicin (Mayan); gato tigre, tigre chico (Panama); pumillo, tigrillo (Peru); hétigrikati (Suriname).

Description and Behavior (Plate 5)

The ocelot is the best known small cat of the Americas, as far as the public is concerned, largely because of the beauty of its coat. Its pelage is short and close (less plush than the similarly patterned margay), and marked with both rosettes and spots which tend to run in parallel chains along the sides of the body. It is also the best-studied (Navarro 1985, Tewes 1986, Emmons 1987, Ludlow and Sunquist 1987, Emmons 1988, Crawshaw and Quigley 1989, Emmons *et al.* 1989, Konecny 1989, Sunquist *et al.* 1989; P. Crawshaw, M. Tewes, pers. comm.). Average weight of adult males is 10 (n=8: Mondolfi 1986) to 11.5 kg (n=8: Enders 1935, Emmons 1988, Sunquist *et al.* 1989), and females 8.8 (n=5: Mondolfi 1986) to 9.4 kg (n=11: Husson 1978, Emmons 1988, Crawshaw and Quigley 1989, Konecny 1989, Sunquist *et al.* 1989).

These studies found terrestrial and nocturnal rodents to be the mainstay of the ocelot's diet. Most frequently taken prey species were those of relatively high abundance, and included cane mice and marsh, spiny, and rice rats (Bisbal 1986, Ludlow and Sunquist 1987, Emmons 1988), opossums and armadillos (Konecny 1989). Ocelots will also take larger prey, including lesser anteaters (Mondolfi 1986, Konecny 1989), red brocket deer (Konecny 1989), squirrel monkeys (Emmons 1988), and land tortoises (the legs of a very young tortoise were found in an ocelot's stomach: Mondolfi 1986). However, most prey taken weighs less than 1-3% of an ocelot's body weight (Ludlow and Sunquist 1987, Emmons 1987); for larger prey species (such as paca and agouti), juveniles are typically taken (Emmons 1987). Ocelots also vary their hunting behavior to take advantage of seasonal changes in prey abundance, such as spawning fish (Emmons 1988) and land crabs (Ludlow and Sunquist 1987) in the wet season. Based on scat analysis, Sunquist *et al.* (1989) found ocelot diet to consist of 65% small rodents, 18% reptiles (mostly iguanas), 7% crustaceans and fish, 6% medium-sized mammals, and 4% birds. Similarly, Emmons (1988) found ocelot diet to consist of 66% small mammals, 5% large rodents, 5% bats and arboreal mammals, 11% birds, 12% reptiles and 2% fish.

Ocelots are strongly nocturnal, resting in trees or dense bush in the daytime; some resting spots are used repeatedly (Emmons 1988), including by different ocelots of the same sex (Ludlow and Sunquist 1987). Ocelots are generally active for more than half of each 24-hour period. Mean daily travel distances range from 1.8-7.6 km, with males travelling up to twice as far as females (Ludlow and Sunquist 1987, Emmons 1988, Konecny 1989). Emmons (1988) estimated ocelot hunting success at 0.9 prey captured per km walked, or one prey captured for every 3.1 hours of travel. Her observations of ocelot hunting behavior suggest that they can follow prey odor trails.

Biology

Reproductive season: (W) Probably year-round, with autumn breeding peaks noted in Texas (Tewes 1986) and Mexico (Leopold 1959); October-January peaks also reported from Paraguay (Rengger 1830) and northeastern Argentina (Crespo 1982).

Estrus: (C) 4.63 ± 0.63 days (n=6).

Estrus cycle: (C) 25.11 ± 4.33 days (n=9: Mellen 1989).

Gestation: (C) 79-85 days (Mondolfi 1986).

Litter size: (C) 1.64 ± 0.21 (n=28: Mellen 1989); range 1-3, mode 1 (Cisin 1967).

Age at independence: (W) not clear, approximately one year, after which sub-adults appear to be tolerated within adult ranges for up to a year (Ludlow and Sunquist 1987, Emmons 1988, Crawshaw and Quigley 1989).

Age at first reproduction: (C) females 18-22 months, onset of spermatogenesis in males at about 2.5 years (Mondolfi 1986); (W) probably related to territory acquisition (L. Emmons *in litt.* 1993).

Interbirth interval: (W) possibly two years (Emmons 1988).

Longevity: (W) 7-10 years; (C) up to 20 years (Sunquist 1992).

Habitat and Distribution

The ocelot is found in every country south of the United States, except Chile, and occupies a wide spectrum of habitats, including mangrove forests and coastal marshes, savannah grasslands and pastures, thorn scrub, and tropical forest of all types (primary, secondary; evergreen, seasonal, and montane—although it typically occurs at elevations below 1,200 m [Mondolfi 1986, Bisbal 1989, Eisenberg 1990]). Availability of sufficient amounts of dense vegetative cover is the common factor linking the various habitat types where ocelots are found (Navarro 1985, Tewes 1986, Ludlow and Sunquist 1987). Emmons (1988) suggests that ocelot microdistribution is more patchy than would be expected by its wide geographical range (Fig. 12), depending upon an abundant rodent prey base and good ground cover. Ocelots generally venture into open areas only on moonless nights or cloudy days (Ludlow and Sunquist 1987, Emmons *et al.* 1989).

The ocelot's known range was extended 350 km southwards when its presence was confirmed in Uruguay (Ximénez 1988). At the northern end of its range, only two significant ocelot populations are believed to persist in the southeastern corner of Texas (Tewes and Everett 1986). Ocelots have been extirpated from Arkansas, Louisiana, eastern Texas, and Arizona, although individuals may occasionally cross into Arizona from Mexico.

Population Status

Global: Category 5a. Regional: Category 4. IUCN: not listed. The ocelot was the spotted cat most heavily exploited by the fur trade from the early 1960s to the mid-1970s: Gieteling (1972) estimated that as many as 200,000 animals were taken every year. From 1976 to 1983, net international trade in skins fell to an average of 24,600 pelts annually, and effectively ceased in the late 1980s (Broad 1987, WCMC unpubl. data) (see Part II Chapter 4). In the early 1980s, Mondolfi (1986) reported that commercial hunting had depleted formerly abundant ocelot populations in Venezuela, but more recently R. Hoogesteijn (*in litt.* 1991) noted that hunting pressure is now greatly reduced, and there are signs of recolonization and recovery. L. Emmons (*in litt.* 1993) notes that, even at the lowest density estimates (one animal per 5 km^2), there would be approximately 800,000 ocelots in forested South America alone, and suggests that true numbers are probably 1.5-3 million.

The ocelot is one of the few small small cats for which spacing and abundance have been studied in several different habitat types.

Lowland rain forest

1. Manu National Park (Peru): Home ranges of two adult females were 1.6 and 2.5 km^2; home ranges of two adult males were 5.9 and 8.1 km^2. Resident animals, particularly males, often patrolled the perimeter of their territories, travelling quickly (8.8-10.4 km/hr) and seldom pausing. Density was high, estimated at four resident ocelots per 5 km^2 (Emmons 1988).

2. Iguaçu National Park (Brazil): From a radiotelemetry study in progress, P. Crawshaw (*in litt.* 1993) reports average home range size for six adult ocelots (2 M, 4 F) as 11.3 km^2.

Figure 12. Distribution of the ocelot (*L. pardalis*).
1. Laguna Atascosa IV (Texas, U.S.); 2. Montes Azules II* (Mexico); 3. Calakmul V* (Mexico) + Maya IX* (Guatemala) complex; 4. Río Platano II* (Honduras); 5. La Amistad II* (Costa Rica and Panama); 6. Darién II# (Panama); 7. Sierra Nevada de Santa Marta II*; 8. Sierra de la Macarena II complex; 9. Chiribiquete II (Colombia); 10. Perij II; 11. Serranía de la Neblina II (Venezuela) and Pico da Neblina II (Brazil) complex; 12. Canaima II; 13. Aguaro-Guariquito II (Venezuela); 14. Trinity Hill IV (Trinidad and Tobago); 15. Yasuní II* (Ecuador); 16. Cerros de Amotape II complex; 17. Pacaya-Samiria VIII; 18. Yanachaga Chemillén II; 19. Manú II# (Peru); 20. Cabo Orange II complex; 21. Jau II complex; 22. Amazonia (Tapajos) II complex; 23. Araguaia II complex; 24. Serra da Capivara II; 25. Pantanal Matogrossense II; 26. Emas II; 27. Serra dos Orgaos II (Brazil); 28. Iguaçu II** (Brazil) + Iguazú II** (Argentina) complex; 29. Sao Joaqim II (Brazil); 30. Bajaga da Pema and Meseta de Artigas reserves (proposed: Uruguay); 31. Baritú II; 32. Fuerte Esperanza I; 33. Agua Dulce Provincial Reserve; 34. Iber IV (Argentina); 35. Tinfunque II; 36. Defensores del Chaco II (Paraguay); 37. Beni I; 38. Manuripi Heath IV complex (Bolivia).

3. Cockscomb Basin Wildlife Sanctuary (Belize): Home range of one adult female was quite large, 14.3 km^2. A sub-adult male had a home range of 31.2 km^2. Most of their territories consisted of secondary forest (Konecny 1989).

Seasonally flooded savannah woodland

4. Venezuelan llanos: Home ranges of two adult males were 9.3 and 11.1 km^2. Mean home range for six adult females was 3.4 km^2 (range 1.7-6.8). Density was estimated at two resident ocelots per 5 km^2 (Ludlow and Sunquist 1987).

5. Brazilian Pantanal: Home ranges (six months only) of two adult females were 0.8 and 1.5 km^2 (Crawshaw and Quigley 1989).

Semi-arid woodland and scrub

6. Southern Texas (U.S.): In dense brush and oak forest mosaic, an adult male maintained a home range of 3.5 km^2, and a female of 2.1 km^2 (Navarro 1985). Working in chaparral habitat, Tewes (1986) found a mean home range for five males of 12.3 km^2 (range 4.6-17.7) and for three females of 7.0 km^2 (range 4.9-9.9).

Protection Status

Upgraded to CITES Appendix I in 1989. National legislation: protected over most of its range. Hunting prohibited: Argentina, Brazil, Bolivia, Colombia, Costa Rica, French Guiana, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Suriname, Trinidad, United States, Uruguay, Venezuela. Hunting regulated: Peru. No legal protection: Ecuador, El Salvador, Guyana (Fuller *et al.* 1987).

Occurrence in Protected Areas

Adjusting for overlapping generations (females) and the fact that males typically mate with more than one female, Ludlow and Sunquist (1987) calculated that a population of 1,334 adult ocelots is required to realize an effective population of 500 ocelots. They used a mean density of 0.38 adult ocelots per km^2, as found for the Venezuelan llanos, to derive a figure of 3,510 km^2 required to support a population of a size sufficient to minimize loss of genetic diversity. Protected areas over 3,000 km^2 are marked in Fig. 12 with a square; other important protected areas are also noted.

Principal Threats

The ocelot has been labelled "one of the most successful forms of mammalian life in the Amazon region" (Grimwood 1969). It is tolerant of disturbed habitat (Vaughan 1983, Tello 1986b), and persists in wooded patches near human settlements (Koford 1976, R. Hoogesteijn *in litt.* 1991). Recent studies, however, depict a more specialized animal operating under rather harsh environmental constraints. Ocelots have a small average litter size, and one of the longest gestations and slowest growth rates among small felids (Fagen and Wiley 1978). Emmons (1988) points out that these reproductive parameters suggest adaptation to low expected rates of energy acquisition, a conclusion supported by findings that ocelots spend long portions of each day hunting. One lactating female increased her daily activity by a maximum of 133% after birth of her litter, but still lost her young to starvation after six weeks—despite high diversity and abundance of small prey in the study area (Emmons 1988).

Emmons (1988) and Sunquist (1992) compare ocelots to bobcats, which have a higher reproductive capacity, although both species are of equivalent weight. The main difference is in their staple prey: for bobcats it is lagomorphs (about 10% of bobcat body weight), while for ocelots it is a variety of small rodents. Emmons (1988) suggests that ocelots may not be able to reproduce where prey density is reduced. The two authors differ, however, on the potential impact of direct human hunting pressure. Sunquist (1992) suggests that, given the ocelot's low recruitment rate, offtake of more than 2-3% of a population per year is likely to be unsustainable and result in declines. Emmons (*in litt.* 1993), on the other hand, believes that the ocelot populations have proved resilient to harvest because of their social organization. A significant proportion of a population consists of non-breeding transients (Emmons 1988), and thus loss of 2-3% of the population would be unlikely to reduce breeding activity substantially.

Action Planning

Projects 96 and 97.

Bobcat, *Lynx rufus* (Schreber, 1776)

Other Names

Lynx roux, chat sauvage (French); Rotluchs, Luchskatze (German); lince, lince rojo, gato montés (Spanish).

Description and Behavior (Plate 6)

The bobcat, named for its short tail (TL=13-20 cm; 13-16% of head-body length: Hall 1981), is a medium-sized cat with a ruff of fur edging the sides of the face. The average weight of adult males ranges from 8.9-13.3 kg, and females from 5.8-9.2 kg (Anderson 1987). The largest verifiable weight recorded is 17.6 kg for an adult male from Minnesota (Berg 1979). Average adult weights and cranial measurements (Samson 1979) indicate that bobcats are larger in the north of their range (Anderson 1987); larger bobcats also tend to occur in more open habitats, with smaller bobcats in forested habitat (Read 1981). Pelt coloration has been variously described as light grey, yellowish brown, buff, brown and reddish brown. Bobcats are always spotted to some extent, with some individuals patterned only on the undersides, others with spots extending up the sides onto the chest and back. Both melanistic and albinistic specimens have been reported (Schantz 1939, Ulmer 1941, Young 1958)—melanism has been found only in Florida (Regan and Maehr 1990). The bobcat may be distinguished from the similar-looking Canada lynx by its shorter hind legs, smaller feet, and shorter ear tufts. The bobcat's tail is black only on the top, whereas the lynx has black all around the tip.

However, as with the lynx, lagomorphs are the bobcat's year-round dietary staple—cottontail rabbits in the south of their range, and snowshoe hares in the north (Maehr and Brady 1986, Anderson 1987, Rolley 1987). Unlike the specialist lynx, however, the bobcat is a generalist and, depending on the locality, rodents also make an important contribution to its diet (Young 1958). In the southern-central Plains and the southern United States, cotton rats are the primary food item (Kight 1962, Beasom and Moore 1977, Miller and Speake 1978, McCord and Cardoza 1982, Leopold and Krausman 1986, Maehr and Brady 1986). Wood rats and kangaroo rats are important in the southwestern U.S. (Leach and Frazier 1953, Gashwiler *et al.* 1960, Small 1971, Jones and Smith 1979). In western Washington state, Knick *et al.* (1984) reported a 42% occurrence of mountain beaver in the diet. In Texas, peccaries are also taken (Leopold and Krausman 1986). Bobcats also take birds (Leach and Frazier 1953, Beasom and Moore 1977, Miller and Speake 1978, Bailey 1979) and bats (Wroe and Wroe 1982).

Despite their small size, bobcats can be effective predators of large adult ungulates, especially deer, generally killed when resting (Matson 1948, Young 1958). Several studies have found that males tend to consume larger prey than females (Fritts and Sealander 1978a, Sweeney 1978, Litvaitis *et al.* 1984), and that juveniles consume proportionally more rodents than adults (Whittle 1979, Toweill 1982). Ungulates can be an important winter food source for northern bobcats, when snow depth increases their vulnerability to predation (Erickson 1955, Fritts and Sealander 1978a, Miller and Speake 1978, May 1981, Litvaitis *et al.* 1986, Koehler and Hornocker 1989). Young fawns are also particularly vulnerable (Beale and Smith 1973, Trainer 1975). Bobcats will also scavenge ungulate carcasses killed by other predators (Koehler and Hornocker 1991).

Bobcats may be active during all hours of the day and night, but studies have consistently found crepuscular (dawn and dusk) activity peaks, a pattern based on the activity patterns of major lagomorph and rodent prey species (reviewed by Anderson 1987, Rolley 1987).

Biology

Reproductive season: (W) Breeding peak late winter (February-March), birth peak early spring (April-May), but in the south of their range litters have been recorded from every month of the year (Anderson 1987, Rolley 1987).

Estrus: (C & W) 5-10 days.

Estrus cycle: (C & W) approx. 44 days (Crowe 1975a, Mehrer 1975). Bobcats may ovulate spontaneously rather than by induction (Duke 1949, Crowe 1975a, Fritts and Sealander 1978b).

Gestation: (C& W) mode 62, range 50-70 days (McCord and Cardoza 1982).

Litter size: (C& W) average 2.6-2.8, range 1-8. Younger females produce consistently smaller litter sizes than older adults (review by Anderson 1987).

Pregnancy rates: (W) as with litter size, probably density-dependent, and generally decline at times of low prey density (Rolley 1983) or high bobcat population density (Lembeck and Gould 1979). Yearling pregnancy rates have ranged from 26-46% (Bailey 1979, Parker and Smith 1983, Rolley 1985), while adult (>3 years) pregnancy rates are much higher at 73-100% (Bailey 1979, Lembeck and Gould 1979, Miller 1980, Parker and Smith 1983).

Interbirth interval: (W) generally one year (McCord and Cardoza 1982, Anderson 1987, Rolley 1987).

Age at sexual maturity: (W) Females are physiologically mature at 9-12 months (Crowe 1975a, Fritts and Sealander 1978b), but probably do not breed until their second year (Pollack 1950, Fritts 1973, Crowe 1975a, Sweeney 1978). The onset of breeding activity may be delayed during prey shortages (Rolley 1985) or in high density bobcat populations (Zezulak and Schwab 1979, Miller 1980). Onset of spermatogenesis in males at 1.5 years (Fritts and Sealander 1978a).

Age at independence: (W) about one year, dispersal occurs during peak of adult breeding activity (Crowe 1975b, Bailey 1981, Griffith and Fendley 1986, Kitchings and Story 1984).

Mortality: (W) From life history tables, Crowe (1975b) estimated annual average juvenile mortality at 26% in Wyoming from 1948-1973 (range 18-71%). Mortality is strongly correlated with prey availability (Bailey 1974, Knick 1990). In protected populations with an abundant prey base, natural adult mortality is low, estimated at 3% in Idaho (Crowe 1975b based on Bailey 1972), and may be slightly higher in high density populations (Lembeck and Gould 1979). In exploited populations, annual adult survival is reduced; estimates of the annual proportion of surviving adults range from 49-67% (Crowe 1975b, Fredrickson and Rice 1979, Hamilton 1982, Parker and Smith 1983, Fuller *et al.* 1985, Rolley 1985, Knick 1990). The highest mortality rate—81%—was found for a legally harvested Minnesota population where illegal hunting was believed to be high (Fuller *et al.* 1985). In general, harvest mortality is greatest among the yearling and 1-2 year-old young adult age classes (Govt. of U.S. 1983a, Litvaitis *et al.* 1987, Knick 1990).

Longevity: (W) 12-13 years (Bailey 1974, Crowe 1975a, Blankenship and Swank 1979); (C) up to 25-33 years (Carter 1955, Jones 1977).

Habitat and Distribution

The majority of the world's bobcats are found in the United States, where they range through a wide variety of habitats, including boreal coniferous and mixed forests in the north, bottomland hardwood forest and coastal swamp in the southeast, and desert and scrubland in the southwest (Fig. 13). In the west, they have been trapped at elevations up to 2,575 m (Govt. of U.S. 1983a). Only large, intensively cultivated areas appear to be unsuitable habitat. Areas with dense understory vegetation and high prey density are most intensively selected by bobcats (Rolley 1987). In Mexico, bobcats are found in dry scrubland and forests of pine and oak, principally in the mountainous northern and central parts of the country, and not in the tropical south (Woloszyn and Woloszyn 1982, Gonzlez and Leal 1984).

Southern Canada represents the northern limit of bobcat range. Bobcat feet are smaller than those of the lynx and lack the large furry pads (Banfield 1974). Parker *et al.* (1983) found that the larger surface area of lynx paws supports twice the weight that of the bobcat can in the snow: this, combined with the bobcat's shorter legs, makes travel in deep snow difficult, and is thus a significant limiting fac-

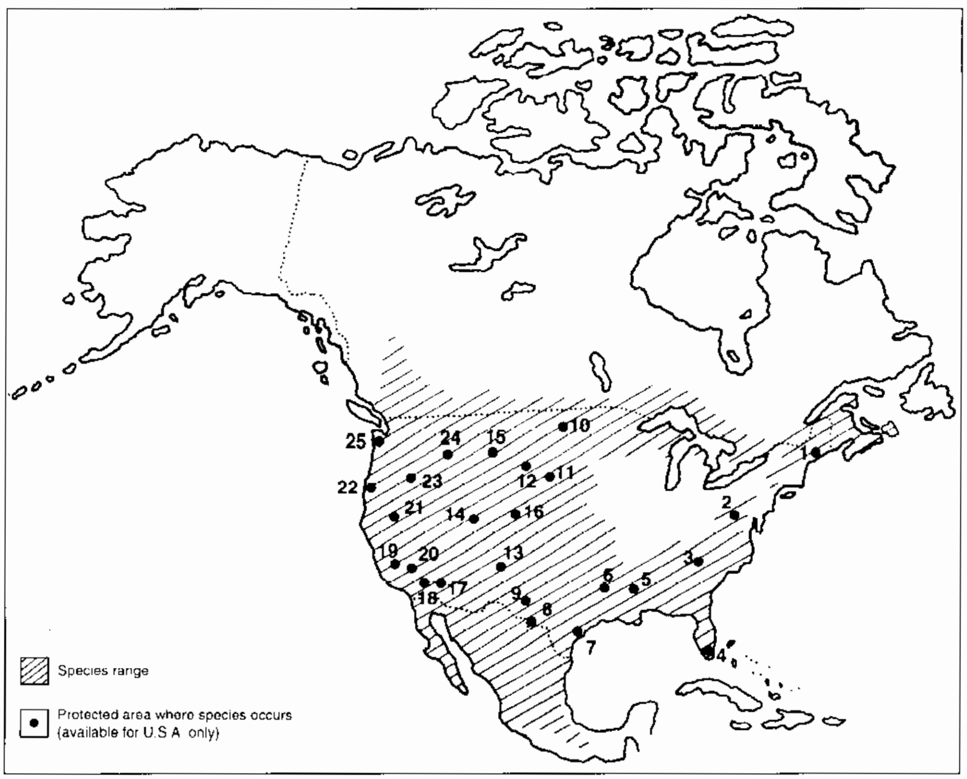


Figure 13. Distribution of the bobcat (*L. rufus*).
1. Mt. Agamenticus Nature Reserve; 2. Shenandoah II; 3. Great Smoky Mountains II**; 4. Everglades II#; 5. Felsenthal IV; 6. Tishomingo IV; 7. Aransas IV; 8. Big Bend II*; 9. Guadalupe Mountains II + Carlsbad Caverns II; 10. Audubon IV; 11. Wind Cave II; 12. Devil's Tower V; 13. Chaco Culture V; 14. Bryce Canyon II; 15. Yellowstone II# complex; 16. Great Sand Dunes III; 17. Kofa IV; 18. Joshua Tree III; 19. Sequoia II complex; 20. Death Valley III; 21. Lassen Volcanic II; 22. Redwood II**; 23. Hart Mountain IV; 24. Frank Church-River of No Return II; 25. Olympic II# (U.S.).

tor in the species' northern distribution. Marston (1942) and McCord (1974) found that snow depths of over 15 cm restrict bobcat movements. In areas where the two cats met, such as Nova Scotia's Cape Breton Island, the more aggressive bobcat has displaced the lynx (Parker *et al.* 1983). A northward expansion of the bobcat's range has taken place over the past century, along with a corresponding northward retreat of the southern boundary of the lynx's range, in association with the clearing for agriculture of mature conifer forests in the region (Rollings 1945, Banfield 1974, Govt. of U.S. 1983b).

Population Status

Global: Category 5a. Regional: Category 4. IUCN: not listed. In the early 1980s, state wildlife authorities estimated the total U.S. bobcat population to range between 725,000 to 1 million adult animals (Govt. of U.S. 1983a). Bobcats have historically been less abundant in the east-central U.S., owing to high human population density and intensive, large-scale agriculture (Peterson and Downing 1952). Bobcats are also considered to be generally widespread and healthy in the Canadian (Govt. of Canada 1983) and Mexican (Govt. of U.S. 1992, M. Aranda *in litt.* 1993) parts of their range, although hunting and trapping may have led to some local depletions (Gonzlez and Leal 1984, G. Mowat *in litt.* 1993). *L. rufus escuinapae* (Allen 1903), the southernmost race found in Mexico, was listed on CITES Appendix I in 1973 for reasons that are not now clear. Craniometric studies have indicated that is is not actually a valid subspecies (Samson 1979), and on these grounds it was downlisted to Appendix II in 1992. The Mexican government has described numbers of bobcat in the country as "adequate" (Govt. of U.S. 1983a, 1992).

Reported bobcat densities range from 1-38 resident adults per 25 km^2 (summarized in McCord and Cardoza 1982, Anderson 1987; Koehler and Hornocker 1989). The southeastern U.S. and California coastal regions appear to support the most dense populations, probably due to high environmental productivity. Reduced density is associated with harsher environments, such as southwestern deserts and the more northern portions of the bobcat's range (summarized in Rolley 1987). Mean home range estimates vary from 0.6-326 km^2 in size (summarized in Anderson 1987), and tend to be larger in the north. For example, Berg (1979) found male ranges averaged 62 km^2 in Minnesota, whereas male ranges in Alabama averaged 2.6 km^2 (Miller and Speake 1979). Male home ranges are generally 2-3 times larger than female ranges and overlap those of several females. Male ranges overlap partially with those of other males, while female ranges are more exclusive.

Protection Status

CITES Appendix II. National legislation: hunting and trade regulated throughout its range (Govt. of Canada 1983, Govt. of U.S. 1983a, 1992). In 1988, 37 states and five Indian groups were authorized by the U.S. government to export bobcat pelts (Anon. 1989a). On a regional level, in the U.S. the bobcat is totally protected in 10 states; in Canada, nowhere; and in Mexico, hunting is regulated in five states, and shooting of suspected livestock predators is permitted on a limited basis (Govt. of U.S. 1983a, Govt. of Canada 1983; M. Aranda *in litt.* 1993).

The degree to which the bobcat has been studied and managed in North America on both the local and national levels makes it probably the most thoroughly examined species in international trade today (Thomsen and Luxmoore 1990, Johnson 1990).

Occurrence in Protected Areas

Bobcats are likely to be found in nearly all protected areas within their range, but confirmed records were available only for U.S. parks and reserves (WCMC, unpubl. data). Refugia play an important role for harvested populations, which are maintained primarily by immigration (Knick 1990). Knick (1990) developed a population model which predicted that the size of refugia needed to maintain a harvested population should be large enough to enclose 3-5 bobcat home ranges. Flores-Villela and Fernández (1989) point out that dryland scrub habitat, important for bobcats in Mexico, is under-represented in the protected areas system.

Principal Threats

In the last 20 years, the bobcat has been the most heavily harvested and traded of the cat species. World demand for bobcat fur rose gradually in the late 1960s and early 1970s and jumped in the mid-1970s after CITES entered into force, when the pelts of cats listed on Appendix I became legally unobtainable for the commercial fur trade (see Part II Chapter 4). Prices offered trappers for bobcat pelts increased sharply from a pre-1970 high of $20 to between $200-300 and as high as $600 in 1979 (Nilsson *et al.* 1980, Johnson 1990). The number of bobcats killed annually in the U.S. consequently climbed to over 90,000 in the 1980s (Govt. of U.S. 1983a); in the 1950s and 1960s about 10,000 bobcats were taken annually in the U.S., increasing to about 44,000 in the 1970s (Johnson 1990). From 1976-1983, Canada reported an average annual harvest of 3,293 bobcats (Govt. of Canada 1983, Shieff and Baker 1987). Although Mexico permits hunting, there is essentially no documented international trade in bobcats from that country (Govt. of U.S. 1992, WCMC unpubl. data).

The financial importance of the trade to the North American range states led to a dramatic rise in research, particularly in the U.S., with a ten-fold increase from the 1960s to the 1970s in studies on population structure, status and distribution (Anderson 1987). Despite the volume of research, there is still concern over whether commercial trapping as practiced in North America is sustainable (see Part II, Chapter 4).

At present, trade in bobcat pelts is declining. Beginning in 1988, both harvest and export of bobcat pelts dropped due to both market shrinkage and market saturation overseas. In addition, the European Union (formerly Community) has announced that, after 1995 (now postponed to 1996), imports of 13 species of wild fur, including bobcat, will be prohibited unless the producer country has either banned the use of the leghold trap or adopted internationally accepted trapping standards (Council Regulations EEC No. 3254/91). Europe is the primary market for bobcat pelts, importing 92% of North America's total overseas exports in 1990 (WCMC unpubl. data). Leghold traps are the main commercial hunting technique used to catch bobcats in North America (Baker and Dwyer 1987, IFTF 1989).

Bobcats are generally not persecuted as pest species in North America. They may occasionally raid poultry, but bobcat depredations have always been uncommon, although bounties were offered by state governments since the 1700s in the U.S. and throughout much of this century (Rolley 1987). In central Mexico, however, the bobcat is reputed to be a major predator of sheep (Govt. of U.S. 1983a), and persecution by ranchers is more frequent (Woloszyn and Woloszyn 1982, Gonzlez and Leal 1984). The dry scrub and oak and pine forest habitats used by bobcats in Mexico have suffered the highest rates of transformation and degradation relative to other habitat types (Flores-Villela and Fernández 1989).

Action Planning

Projects 17 and 104.

Pampas cat, *Oncifelis colocolo* (Molina, 1782)

Other Names

Chat des pampas (French); Pampaskatze (German); gato pajero, gato de los pajonales, osio (Spanish); gato de pajonal (Argentina, Ecuador, Peru, Paraguay); gato montés (Bolivia, Chile, Ecuador, Peru, Paraguay); gato peludo (Bolivia); gato palheiro (Brazil); gato colocolo (Chile); gatillo (Ecuador); osjollo, chinchay (Peru).

Description and Behavior (Plate 4)

The pampas cat has a wide distribution and broad habitat selectivity, and its appearance varies in different parts of its range. In the high Andes, it is grey-colored with reddish stripes broken up into spots, and looks rather similar to the Andean mountain cat, although it is not so heavily striped. In the Argentine pampas, the coat is longer, of a more yellow-brown color, with muted pattern (Cabrera and Yepes 1960). A male from central Brazil was of rusty color with dark and conspicuous irregular black stripes over its entire body when young (three months old), but by the age of eight months, stripes were visible only on the limbs and underparts (Silveira in submission).

A taxonomic evaluation of 96 museum specimens leads García-Perea (1994) to propose that, given pronounced geographic differences, the "pampas cat" is actually three species: *Lynchailurus pajeros* (Desmarest, 1816) [high Andes from Ecuador to Patagonia and throughout Argentina]; *L. braccatus* (Cope, 1889) [warm grassland and sub-tropical forest in Brazil, Paraguay and Uruguay]; and *L. colocolo* (Molina, 1782) [central and northwestern Chile]. She plans to test the degree of differentiation between the three types by molecular analysis.

The long hairs on the pampas cat's back (up to seven cm in length) form a sort of dorsal mane: when it sets its hairs on end, it looks larger than it really is, which is only a little bigger than a domestic cat. The recorded wild-caught weights range from 3-3.7 kg (n=3: Redford and Eisenberg 1992, Silveira in submission). In captivity, they have weighed up to 7 kg (Green 1991).

Although the pampas cat is relatively common and widespread, there is surprisingly little data available on its ecology. It has been described as preying chiefly on small mammals such as guinea pigs (Cabrera and Yepes 1960, Guggisberg 1975, Ferrari *et al.* 1984, Rabinovich *et al.* 1987, D. Brooks *in litt.* 1989), as well as ground-dwelling birds—for example, in Patagonia pampas cats have been observed to take penguin eggs and chicks from nests (D. Boersma *in litt.* 1990). Pampas cats are thought to be predominantly nocturnal and terrestrial. However, they have been observed in daylight hours in the wild, and a male pampas cat kept in Brazil's Parque Zoológico de Goiânia showed great skill in tree climbing, and spent most of its resting periods draped over the highest fork of a small dead tree installed in its cage (Silveira in submission).

Biology

Reproductive season: (C) April-July (northern hemisphere) (Green 1991).

Litter size: (C) 1.31 ± 0.13 (n=13) (Mellen 1989); range 1-3 (Rabinovich *et al.* 1987).

Age at first reproduction: (C) two years (n=1 female: Eaton 1984).

Longevity: (C) average nine, but up to 16.5 years (n=3) (Prator *et al.* 1988).

Habitat and Distribution

The pampas cat is strongly associated with grass and shrub

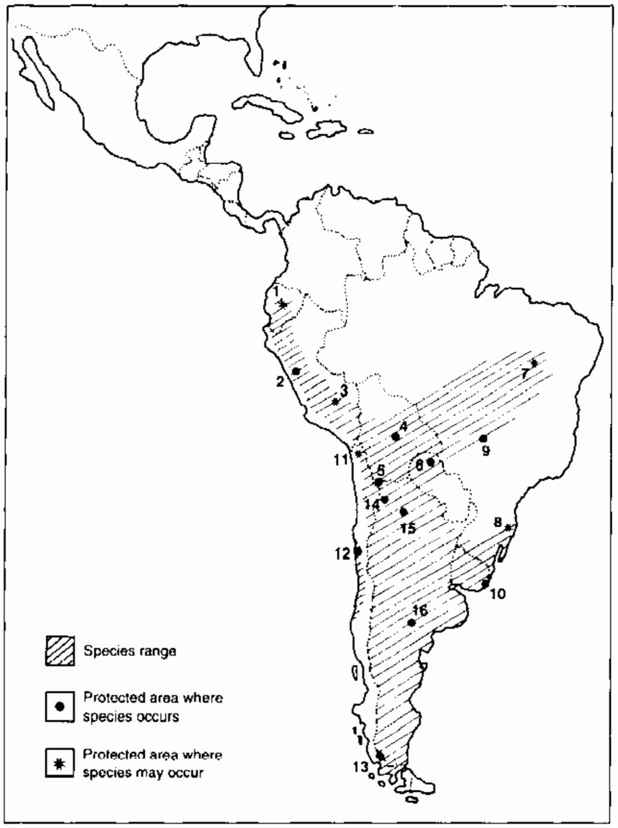


Figure 14. Distribution of the pampas cat (*O. colocolo*).
1. Sangay II** (Ecuador); 2. Huascarn II#; 3. Manú II# (Peru); 4. Amboró II complex; 5. Eduardo Avoroa IV (Bolivia); 6. Defensores del Chaco II (Paraguay); 7. Serra da Capivara; 8. Aparados da Serra II; 9. Emas II (Brazil); 10. Dunas de Cabo Polonio III (Uruguay); 11. Lauca II* complex; 12. Bosque Fray Jorge II*; 13. Torres del Paine II* complex (Chile); 14. Los Andes I; 15. La Florida V complex; 16. Lihuel Calel II complex (Argentina).

habitats (Fig. 14). In addition to the pampas grassland formations for which it is named, it also occurs throughout the cerrado (open wood, shrub, and grass complexes) of central Brazil (L. Silveira in submission). The pampas cat also occurs in several forest types, typically open woodland or scrub thicket, such as the Gran Chaco, but also the belt of "yungas" cloud forest that runs along the eastern slope of the Andes (Cabrera 1961, Grimwood 1969, Cabrera and Willink 1980). It is absent only from lowland rain forest, both tropical (Emmons 1990) and temperate Valdivian (Taber *et al.* 1974). At the southern extent of its range, it occurs in the cold semi-arid desert of Patagonia. In Uruguay, it is found in low-lying swampy areas with clumps of long esparto grass (Ximénez 1961), and also occurs around the Pantanal floodplain (L. Silveira in submission). It occurs on both the eastern and western slopes of the Andes, with an elevational range from 100 up to over 5,000 m, where it is possibly sympatric with the Andean mountain cat (Grimwood 1969, Redford and Eisenberg 1992).

The range portrayed in Fig. 14 assumes that pampas cat populations are largely continuous. However, in keeping with her theory that there are actually three different species of pampas cat, García-Perea (1994) has produced an alternative range map showing disjunct distributions (Fig. 15). The range she portrays in south-central Brazil should be extended to the east as shown in Fig. 14, based on specimen records collected by Silveira (in submission).

Population Status

Global: Category 5a. Regional: Category 4. IUCN: Indeterminate. The pampas cat is widely distributed, tolerant of altered habitat (including secondary growth, forest plantation, and the fringes of agricultural and settled areas: P. Crawshaw, C. Weber *in litt.* 1993), and international trade in its pelt ceased in 1987 (WCMC unpubl. data). In the Paraguayan Chaco, it has been described as less common than the Geoffroy's cat (Brooks 1992). Although

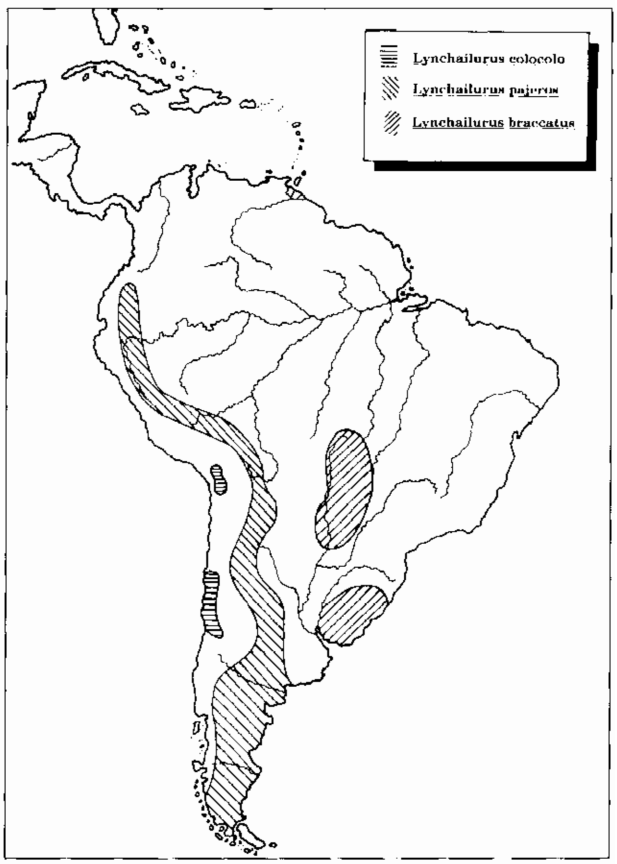


Figure 15. Distribution of proposed three species of pampas cat according to García-Perea (1994).

pronounced extinct in Uruguay over 30 years ago (Cabrera and Yepes 1960), it probably still exists, but very sparsely due to draining of wetlands for ranching and agriculture (A. Ximénez *in litt.* 1991). Although it appears to have a wide range in Brazil (the cerrado is Brazil's second largest habitat type after tropical rain forest: Olson *et al.* 1983), records are scarce and the species is generally considered rare (L. Silveira in submission). The pampas cats of Chile (*L. colocolo* of García-Perea [1994]) are the most endangered group due to small geographic range.

Protection Status

CITES Appendix II. National legislation: protected across most of its range. Hunting prohibited: Argentina, Bolivia, Chile, Paraguay. Hunting regulated: Peru. No legal protection: Brazil, Ecuador. No information: Uruguay (Fuller *et al.* 1987).

Principal Threats

The pampas region of Argentina and Uruguay has been heavily settled and grazed relative to other regions, and the status of the species should be investigated here. The pampas cats of Argentina were formerly hunted in large numbers for the fur trade—78,000 skins were exported from 1976-1979 (Mares and Ojeda 1984)—but international trade has ceased following a last shipment of 10,000 pelts exported in 1987 to clear old stocks (WCMC unpubl. data). L. Silveira (in submission) reports that the pampas cat is known to raid chicken houses occasionally.

Action Planning

Projects 99 and 105.

Jaguarundi, *Herpailurus yaguarondi* (Lacépède, 1809)

Other Names

Otter cat (English); jaguarondi (French); Jaguarundi, Wieselkatze, Eyra (German); yaguarundi, onza, gato moro, gato eyra (Spanish); halari (Belize); maracaja-preto, gato-preto, gato mourisco (Brazil, Uruguay); gato griz (Bolivia); gato pardo, gato servante, ulama (Colombia); leon breñero (Costa Rica, Peru); jaguarondi, chat noir (French Guiana); tejón, mbaracaya-eira (Guatemala); gato cerban (Honduras); kakicoohish (Kekchi); ekmuch (Mayan); tigrillo congo, tigrillo negro (Panama); leoncillo, anushi-puma (Peru); boesikati (Suriname); gato cervantes (Venezuela).

Description and Behavior (Plate 4)

The jaguarundi has a distinctly weasel-like appearance, with its elongated slender body, short legs, and sleek unpatterned fur. The jaguarundi also differs from the other small cats of Latin America by its elongated rather than rounded head (Eisenberg 1990). Reported adult weights range from 2-9 kg (Mondolfi 1986, Guggisberg 1975). In Belize, two males averaged 5.9 kg and two females 4.4 kg (Konecny 1989). There are three different color forms, which may sometimes occur in the same area or even the same litter (Konecny 1989, Brooks 1992)—black, brownish grey, and red. In general, however, the darker colors are most commonly associated with inhabitants of rain forest habitats, while the paler color is found most frequently in drier environments (Emmons 1990). The red form was once considered a separate species *F. eyra* (Fischer, 1814).

It has been suggested that the jaguarundi prefers to hunt ground-dwelling birds rather than mammals (Gaumer 1917, Leopold 1959, Hall and Dalquest 1963), and analysis of 23 stomachs from Venezuela (Mondolfi 1986, Bisbal 1986) shows that birds are frequently caught (found in 54-70% of the stomachs). Rodents, rabbits, and reptiles were also found in 40-51% of the stomachs. In Belize, scat analysis indicated that arthropods are frequently eaten (remains found in 72% of scats); birds occurred in 22% of scats and rodents in 95% (Konecny 1989). Jaguarundis have also been observed to prey upon characid fish stranded in a puddle (Manzani and Monteiro 1989).

Rengger (1830) suggested that the solid coat of the jaguarundi is probably associated with the fact that these cats hunt more diurnally or terrestrially than spotted felids. While nocturnal activity (as well as arboreal foraging) is occasionally observed (Leopold 1959, Guggisberg 1975, McCarthy 1992), Konecny's (1989) radiotelemetry study of four jaguarundis in Belize found the period of peak activity to be 0400-1100, with only residual activity (movements of less than 100 m/hr) after sunset. Jaguarundis have been frequently observed travelling or foraging in pairs (Rengger 1830, Guggisberg 1975, McCarthy 1992).

Biology

Estrus: (C) 3.17 ± 0.75 days (n=6).

Estrus cycle: (C) 53.63 ± 2.41 days (n=8: Mellen 1989).

Gestation: 70-75 days (Hulley 1976, P. Andrews *in litt.* 1993).

Litter size: (C) 1.83 ± 0.24 (n=12: Mellen 1989); range 1-4 (Hulley 1976).

Age at sexual maturity: (C) 2-3 years (Hulley 1976, P. Andrews *in litt.* 1993).

Longevity: (C) up to 15 years (Prator *et al.* 1988).

Habitat and Distribution

A cat of the lowlands not generally found above 2,000 m

(Vaughan 1983), the jaguarundi otherwise occupies a broad range of both open and closed habitats—from dry scrub, swamp, and savannah woodland to primary forest. In Venezuela, it has been most frequently collected in tropical dry forest, relative to other habitat types (Bisbal 1989). Jaguarundis are more rare and thinly distributed in moist forest types, especially deep rain forest (Konecny 1989, L. Emmons *in litt.* 1993). Jaguarundis have been reported to prefer forest edges and secondary brush communities (Bourlière 1955, Mondolfi 1986), but this may be because it is in such areas that these primarily diurnal cats are most frequently seen. In Belize's Cockscomb Basin Wildlife Sanctuary, Konecny (1989) found that jaguarundis are most frequently associated with riparian and old field habi-

Figure 16. Distribution of the jaguarundi (*H. yaguarondi*).
1. Laguna Atascosa IV (Texas, U.S.); 2. Cockscomb Basin IV (Belize); 3. Volcn de Pacaya III (Guatemala); 4. Río Platano II* (Honduras); 5. Braulio Carrillo II complex (Costa Rica); 6. Barro Colorado II (Panama); 7. Isla de Salamanca II (Colombia); 8. Guatopo II (Venezuela); 9. Purac* II (Colombia); 10. Pacaya-Samiria VIII; 11. Manú II# (Peru); 12. Manuripi Heath IV complex (Bolivia); 13. Iguazú II** (Argentina) + Iguaçu II** (Brazil) complex; 14. Lihuel Calel II complex (Argentina).

tats. Access to dense ground vegetation appears to determine habitat suitability for the jaguarundi, but of all the small New World felids, it is most flexible in its ability to occupy diverse environments (Fig. 16).

Population Status

Global: Category 5c. Regional: Category 5. IUCN: not listed. The jaguarundi appears to be relatively common over much of its range (Koford 1976, Vaughan in press) although, while present throughout the Amazon basin rain forest, it is more rare in this habitat type (L. Emmons *in litt.* 1993). The jaguarundi may now be extinct in Uruguay (Thornback and Jenkins 1982), and is very rare in the southwestern United States near the Rio Grande (Tewes and Everett 1986).

In Belizean rain forest, home ranges for male jaguarundis were very large (Konecny 1989), several times larger than those reported for sympatric jaguars weighing nearly 10 times more (Rabinowitz and Nottingham 1986). One female used a home range that varied between 13-20 km^2, while two males used home ranges of 100 and 88 km^2. The home ranges of the two males overlapped less than 25%. Both sexes exhibited a pattern of using different, widely spaced portions of their ranges for irregular periods of time, rather than making regular boundary patrols (Konecny 1989).

Protection Status

CITES Appendix II; Central and North American populations Appendix I since 1987. National legislation: protected over much of its range. Hunting prohibited: Argentina, Belize, Bolivia, Colombia, Costa Rica, French Guiana, Guatemala, Honduras, Mexico, Panama, Paraguay, Suriname, Uruguay, United States, Venezuela. Hunting regulated: Peru. No legal protection: Brazil, Nicaragua, Ecuador, El Salvador, Guyana (Fuller *et al.* 1987).

Principal Threats

Generally not exploited for commercial trade, although jaguarundis are doubtless caught in traps set for commercially valuable species and may be subject to low intensity hunting pressure around settled areas. They are notorious for predation on domestic poultry (Rengger 1830, Alvarez del Toro 1952, Leopold 1959, Hall and Dalquest 1963, Goodwyn 1970, Koford 1976, Ferrari *et al.* 1984, Bisbal 1986, McCarthy 1992).

Wild Cats of Africa

Peter Jackson

African lions (*Panthero leo*). Lions are increasingly confined to reserves because they are persecuted in livestock zones.

Paul Leyhausen

Lion in Rabat Zoo, Morocco, in 1974, showing characteristics of the extinct lion of north Africa, the type locality for Linnaeus' *Felis leo* 1758.

Tom Brakefield

African leopard (*Panthera pardus*). The leopard is common in many parts of sub-Saharan Africa. Its range extends eastwards across Asia to the Sea of Japan.

Barbara Tonkin

African golden cat (*Profelis aurata*). Although it has distinct similarities with the Asiatic golden cat, the African golden cat is now placed in a separate genus.

Paul Leyhausen

African golden cat (*Profelis aurata*). Both African and Asiatic golden cats have prominently spotted forms.

Wild Cats of Africa

Peter Jackson

Cheetah (*Acinonyx jubatus*). Although reduced in numbers, it is still widespread on the plains of sub-Saharan Africa.

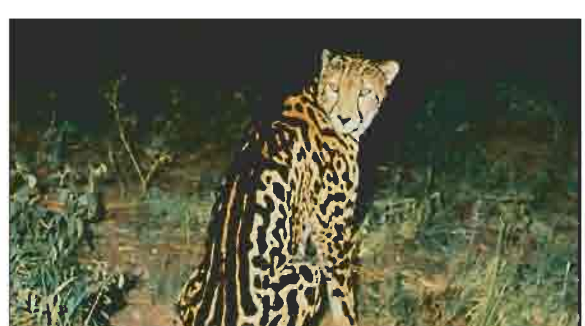
agesco-Joffé

assel

Peter Jackson

Cheetah (*Acinonyx jubatus*). Although reduced in numbers, it is still widespread on the plains of sub-Saharan Africa.

agesco-Joffé



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Wild Cats of Africa

Kailash Sankhala

The caracal (*Caracal caracal*) is common in southern Africa, where it is persecuted as a livestock pest, but it is rare in its Asian range, which extends into India.

Alexander Sliwa

A black-footed cat (*Felis nigripes*), radio-collared during an ecology study in South Africa.

Alain Dragesco-Joffé

The African wildcat (*Felis silvestris, libyca* group) is threatened genetically by inbreeding with its descendant, the domestic cat.

Alain Dragesco-Joffé

Sand cat (*Felis margarita*), found in the Sahara and through the deserts of Asia, as far as Pakistan and Turkmenistan.

Wild Cats of the Americas

Rafael Hoogesteijn

Jaguar (*Panthera onca*). Named "El tigre" by Spanish explorers, who recalled the tiger in Asia, its present range is South and Central America, but formerly extended to the southern U.S.A.

Francisco Erize

Puma (*Puma concolor*). Early explorers gave it the name "mountain lion" because of its resemblance to the African lion.

Tony Rath/WWF

Jaguarundi (*Herpailurus yaguarondi*). A genuine cat despite its resemblance to mongooses and otters.

Francisco Erize

Francisco Erize

Pampas cat (*Oncifelis colocolo* ssp.). Three subspecies of the pampas cat with distinctive coat patterns and isolated ranges have been proposed as full species. These two photos show coat patterns from different areas.

Wild Cats of the Americas

Tony Rath/WWF

Ocelot (*Leopardus pardalis*). The coat patterns of the related ocelot, margay, and oncilla vary only slightly, and they have all been traded as "ocelot."

Günter Ziesler

Margay (*Leopardus weidi*). Smaller than the ocelot, the margay is renowned for its flexible hind feet, which enable it to descend vertical tree trunks head-first.

Rafael Hoogesteijn

Oncilla (*Leopardus tigrinus*). Smallest species of the genus *Leopardus*.

Wild Cats of the Americas

Tom Brakefield

The Canada lynx (*Lynx canadensis*) population fluctuates in relation to the highs and lows of its prey, the snowshoe hare.

Tom Brakefield

Bobcat (*Lynx rufus*). Common in the U.S.A., the bobcat is extensively exploited for the fur trade.

Francisco Erize

Geoffroy's cat (*Oncifelis geoffroyi*). Most common of the small cats in southern South America.

E. Ramito

The kodkod (*Oncifelis guigna*) is one of the world's smallest cats and may be a subspecies of Geoffroy's cat.

Günter Ziesler

A rare photo of the Andean mountain cat (*Oreailurus jacobitus*), mystery cat of the high Andes.

Wild Cats of Asia

Peter Jackson

Bengal tiger (*Panthera tigris tigris*). Most numerous of the surviving tiger subspecies, the Bengal tiger is seriously threatened by poaching.

Peter Jackson

Amur (Siberian) tiger (*P.t. altaica*). Largest of all the cats, now threatened again by hunting after a remarkable recovery from low numbers earlier in this century.

Caspian tiger (*P.t. virgata*). Extinct since the early 1970s from hunting and settlement in its range. This photo of a tiger from the Caucasus in Berlin Zoo was published in 1899.

Peter Jackson

South China tiger (*P.t. amoyensis*). Now rare, it lives in the region where the tiger is thought to have originated.

Peter Jackson

The Indo-Chinese tiger (*P.t. corbetti*) is smaller and darker than the Bengal tiger.

R. Idzerda

Bali tiger (*P.t. balica*). Extinct since the 1940s, it was only half the size of an Amur tiger. This specimen was shot in 1925.

A. Hoogerwerf

Javan tiger (*P.t. sondaica*). Extinct since the early 1980s from hunting and settlement in its range. The photo was taken in 1938 in Ujung Kulon.

Peter Jackson

Sumatran tiger (*P.t. sumatrae*), the last survivor of the island tigers of Indonesia. It is the same size as the extinct Javan tiger.

Wild Cats of Asia

Eskander Ferouz

Asiatic cheetah (*Acinonyx jubatus venaticus*). A young specimen of the last of the Asiatic cheetahs lying in the snow in Iran.

Peter Jackson

Asiatic lion (*Panthera leo persica*). Now confined to a single population in India, the Asiatic lion is distinguished from the African by a sparser mane and fleshy belly fold.

Dimitriy Pikunov

Amur (Far Eastern) leopard (*Panthera pardus orientalis*). The most northerly leopard subspecies, critically endangered with extinction.

Peter Jackson

Clouded leopard (*Neofelis nebulosa*). The coat pattern resembles that of the much smaller marbled cat.

Kathleen Conforti

Marbled cat (*Pardofelis marmorata*). Despite its small size, the marbled cat is considered to be closely related to the big cats.

Wild Cats of Asia

E.P. Gee

Asiatic golden cat (*Catopuma temmincki*). Although resembling the African golden cat, the Asiatic species is placed in a separate genus.

Peter Jackson

Asiatic golden cat (*C.t. tristis*). This photo shows a subspecies, found in China, with an "ocelot" coat pattern.

Fiona Sunquist

Bornean bay cat (*Catopuma badia*). No living specimen has been photographed. This cat, held by Dr. Charles Leh, was caught by trappers in 1992 on the Sarawak-Indonesia border, but died before scientists could examine it.

Nat. Hist. Museum, London

Bornean bay cat (*Catopuma badia*) in a 19th century painting by Joseph Wolf.

Wild Cats of Asia

E.P. Gee

Leopard cat (*Prionailurus bengalensis*). The most common small cat in Asia.

Masako Izawa

Iriomote cat (*Prionailurus bengalensis iriomotensis*). Although now classified as a subspecies of leopard cat, some taxonomists insist that it is a full species.

Bholu Abrar Khan

The fishing cat (*Prionailurus viverrinus*) is threatened by destruction of wetlands in tropical Asia.

Barbara Tonkin

Flat-headed cat (*Prionailurus planiceps*). Little is known of this small fish-eating cat of southeast Asia.

Bharat Pathak

Rusty-spotted cat (*Prionailurus rubiginosus*), found in Sri Lanka and India, where it has made dens in human habitations.

Günter Ziesler

The jungle (swamp) cat (*Felis chaus*) is found mainly in tropical Asia, but also in Arabia and the Nile Valley in north Africa.

Wild Cats of Eurasia

Helen Freeman

Snow leopard (*Uncia uncia*). The spread of livestock and killing of its natural prey threaten this cat of the high mountains of central Asia.

Gunter Ziesler

Eurasian lynx (*Lynx lynx*). Extirpated in western Europe in the 19th century, lynx have been reintroduced in the Alps and some other regions.

J J Aldama

Iberian lynx (*Lynx pardina*). Most threatened of all cat species, the small Iberian lynx has suffered severe loss of habitat, and its main prey, the rabbit, has declined because of the disease myxomatosis.

Peter Jackson

Chinese mountain cat (*Felis bieti*), found only in the rocky areas of the northeastern Tibetan Plateau in China.

Wild Cats of Eurasia

Gunter Ziesler

European wildcat (*Felis silvestris*). Like its close relative, the African wildcat, the European wildcat is threatened genetically in many areas by interbreeding with domestic cats.

Kailash Sankhala

Asiatic wildcat (*Felis silvestris, ornata* group). This cat has been heavily exploited in India and Pakistan for its spotted fur.

Jill Mellen

Manul (*Otocolobus manul*), a thickly-furred cat of central Asia, which was once wrongly thought to be an ancestor of the domestic Persian cat.

Part II
Major Issues in Cat Conservation

Chapter 1
Cats and Habitat Loss

Introduction

This planet's land area amounts to over 148 million km^2. With the total human population at over 5.3 billion, this amounts to a density of more than 40 people per km^2 (excluding 18 million km^2 of the Antarctic land mass and the area taken up by lakes). The human population has more than doubled since 1950, and is projected to reach 8.5 billion by 2025. Despite a worldwide decline in the birth rate since 1970, demographers say that the total population will continue to increase simply because more people than ever before will reproduce. It is projected to continue growing over the next 200 years, eventually stabilizing at 11.6 billion in 2200—or about 90 people per km^2 (WRI/UNEP/UNDP 1992).

In order to support this growth, wild lands are coming under increasing use and development. Figure 1 shows the degree of human modification around the globe. Loss and fragmentation of habitat are often the primary cause of species extinctions and the decline of biodiversity (WCMC 1992). The increase in the number of people in the world and the decline in the amount of wilderness area will continue unless fundamental changes are made in our economic and social systems globally, nationally, and locally, to make the present way of development into a sustainable process (IUCN/WWF/UNEP 1991).

This chapter has two primary purposes. The first is to present an overview of the status of the world's habitats, and to evaluate the implications for cat conservation. Critical habitat types for cats are identified, and global trends in habitat loss and fragmentation are reviewed. Given the socio-economic pressures referred to above, there is a certain amount of inevitability in these trends, but there is also room for optimism regarding the potential to conserve cats in a variety of human-modified habitats. This will require that cat specialists take an active role in development-related work which lies outside the realm of traditional research activities. The second purpose of this chapter is to review the protected areas of the world in terms of cat conservation, and focus on what changes are needed to make them more suitable havens for cats.

Habitats for Cats

A global overview of the world's habitats in relation to cat distribution calls for habitats to be grouped according to similarities. There is currently no universally recognized global habitat classification scheme. The various schemes are based on either (1) distinct communities of plant species (taxonomy) or (2) similarities in plant physiognomy (structure: forest, grassland), phenology (evergreen, deciduous), or environmental variables (altitude, climate, hydrology) (WCMC 1992, Anon. 1993d). One of the latter types of classifications is used here because it is clear, generally speaking, that the physical nature of the environment has been a powerful selective force shaping cats (Eisenberg 1981: 211). Examples include the snow leopard's pale coat, the arboreal margay's flexible ankles, and the sand cat's fur-covered paws. Cats have a rather indirect relationship with plant species, unlike their mainly herbivorous prey. It is expected that when the world's scientists finally agree upon and develop a universally accepted habitat classification scheme, vegetation structure will be the primary basis (Anon. 1993d). It is hoped that this sort of classification adequately reflects the way cats perceive and select habitat.

The map of major world ecosystem complexes developed by Olson *et al.* (1983) (Figs. 2a-f) uses a classification system developed principally to refine global estimates of the amount of carbon contained in plants, so that similarities in vegetative structure (rather than species composition) are emphasized in the definition of habitat types. Unlike other major habitat classifications, large areas of human-modified environments, such as rice paddies or settled areas, are included as distinct "ecosystems." This is of key importance, as human-modified vegetation comprises most of the world's land surface, far out-stripping natural, original vegetation (Fig. 1; Anon. 1993d: 9).

The definition of each habitat type is given in Table 1, and Figs. 2a-f map the global distribution of these habitat types as of 1980. Table 2 lists habitat types, their global area, and the number of cat species associated with each type. As a component of cat species vulnerability ranking,

Box 1
Habitat Classification and Species Associations

Olson *et al.* (1983) originally designated 47 land-based habitat types, which have been combined here to yield a total of 21. For example, where their original map distinguished three sub-types of temperate broad-leaved forest, they are combined here. Type definitions are given in Table 1. Each cell or pixel in the map represents an area of 0.5 degrees latitude by 0.5 degrees longitude, or 55 x 55 km at the equator = 3,025 km^2. Using a variety of vegetation and land-use maps and data sources, Olson *et al.* (1983) assigned each pixel to its predominating habitat type. To reduce bias, several habitat types were defined as vegetative mosaics, such as 2c, other dry woods/scrub/grass complexes. With such a large pixel size, however, loss of detail is inevitable. As discussed later in this chapter, most of the world's protected areas are well under 3,000 km^2 in size. If surrounded by human-modified landscape, these patches of natural habitat generally do not show up on the map.

Species-habitat association was defined as either strong, significant, marginal or absent. Habitat associations are given for each species in Appendix 4. When sufficient reference material was available (references are given in the Species Accounts), degree of association was assigned according to relative abundance of a species within a given habitat type. Degree of association was also based upon how large a proportion of a species' total contemporary range is taken up by a particular habitat type. Relative abundance and relative area are not always congruent. For example, northern taiga forest (habitat type 2d) occupies more of the Eurasian lynx's range than do southern taiga and other coniferous forest (habitat types 1a and 1b), but the lynx occurs at greater densities in the latter (Matjuschkin 1992). Similarly, although broad-leaved humid forest (habitat type 1e) occupies a major portion of the jaguarundi's range, the jaguarundi is sparsely distributed in dense primary forest compared to more open habitats (L. Emmons *in litt.* 1993). There were not sufficient data available to use either relative abundance or area consistently. However, to compensate as far as possible, assignment of degree of association in this study is conservative.

In addition, a habitat type which occupies only a small portion of a species' range was defined as significant if it harbors an important sub-population: for example, coniferous forest (habitat type 1b) for the Siberian tiger, or mixed woods (1d) for the north African serval.

species-habitat associations were defined as strong, significant, marginal, or absent (see Box).

Generally speaking, cats make use of a variety of broadly defined habitats. The average number of habitats in which cat species occur is 7.5 (SD=3.49; mode=7; range = 2-15), or just over one-third of the 21 habitat types. The average number of strong and significant habitat associations per species is 4.6 (SD=2.19; modes=2 & 4; range = 1-10), or about one-fourth of the total available habitat types. Only one habitat type, polar ice and desert (5b), lacks a member of the cat family.

From the data in Table 2, the importance of forest habitat to cats is immediately evident. Closed and open woodlands cover approximately 40% of the Earth's land area, and harbor 89% of the cat species (32 of 36 species). Closed forest is particularly important habitat. This makes sense: cats, with their adaptations for climbing and stalking, are believed to have evolved from a forest-dwelling miacid ancestor (Ewer 1973, Leyhausen 1979, Eisenberg 1986). Only four species are adapted to live wholly in sparsely vegetated environments characterized by lack of trees: black-footed cat, sand cat, Andean mountain cat, and manul.

Mammalian species richness is greatest in tropical moist forest (Eisenberg 1981), which covers only about 7% of the Earth's land area, but constitutes a major part of the ranges of nearly half of the cat species. Both tropical humid forest (habitat type 1e) and grassland and shrubland (habitat type 4a) each have 14 species strongly associated with them—almost twice as many as the next most species-rich habitat type, tropical savannah and woodland (2a), with eight species strongly associated. Compared to other habitat types, however, tropical humid forest is notable for its lack of species which are marginally or significantly associated. Only three species are significantly associated with tropical humid forest—the jaguarundi, jungle cat, and oncilla. The jaguarundi occurs throughout the humid forests of Latin America, but at low densities in dense primary forest, while the oncilla appears to be absent from the lowland humid forests of the Amazon basin, although it is present in humid forests to the north. The jungle cat is also thinly distributed in drier parts of the humid forests of tropical Asia. Still, tropical humid forest makes up large portions of these species ranges—no cats are marginally associated with this habitat type. In general, it seems that cats are either strongly tied to rain forest, or otherwise not at all.

While the overall felid trend is toward broad habitat selectivity, a substantial minority are more specialized. As shown in Table 3, 14 species (39% of the family) are classified as narrow in habitat association, being associated with a total of six or fewer habitat types. This point should be qualified, however, by noting that the majority of these are small, poorly studied cats (e.g., compare with Table 1 on research effort in Chapter 3), and future field work is needed to confirm habitat associations. Of these 14 species, seven, or 50%, are strongly or significantly associated with tropical rain forest, a proportion very similar to that for the cat family as a whole (47%). In other words, habitat specialists are not more likely to be strongly associated with tropical rain forest than more generalist cats.

Habitat specialization does not necessarily correlate with vulnerability, however. Considering the 19 species ranked in Categories 1-3, which are of highest global conservation priority, it can be seen that a slightly greater proportion, when compared with all felids, is associated with tropical rain forests. Table 4 lists habitat types with the highest percentages of Category 1-3 cats closely (strongly and significantly) associated. In addition to tropical moist forest, other habitats which are relatively more important for vulnerable cats include major wetlands (habitat type 6), tropical montane complexes (2b), and high alpine tundra (5a). These three habitats share the features of being small in overall area, and locally patchy or insular. With the exception of high alpine tundra, all have decreased in area over the 1980s, as discussed below.

Habitat Loss and Fragmentation: An Overview of Global Trends

Habitat Loss

There are currently no global systems which monitor the status of a standardized, globally recognized set of habitat types, although the conservation community has recognized the need for such a system and made its development a priority (Anon. 1993d). Detailed quantitative data is available, in reality, only for tropical forests (C. Billington, World Conservation Monitoring Centre, pers. comm. 1994), and the "state of the art" is the United Nation's Food and Agriculture Organization's Forest Resources Assessment 1990 Project (FAO 1993; J. Blockhus, IUCN Forest Conservation Programme, pers. comm. 1994). Tropical moist (includes rain forest) and dry forests harbor 68% of the vulnerable Category 1-3 cats (13 species), and 64% of all the species in the family Felidae (23 species; see Table 7). Moreover, as pointed out above, cats

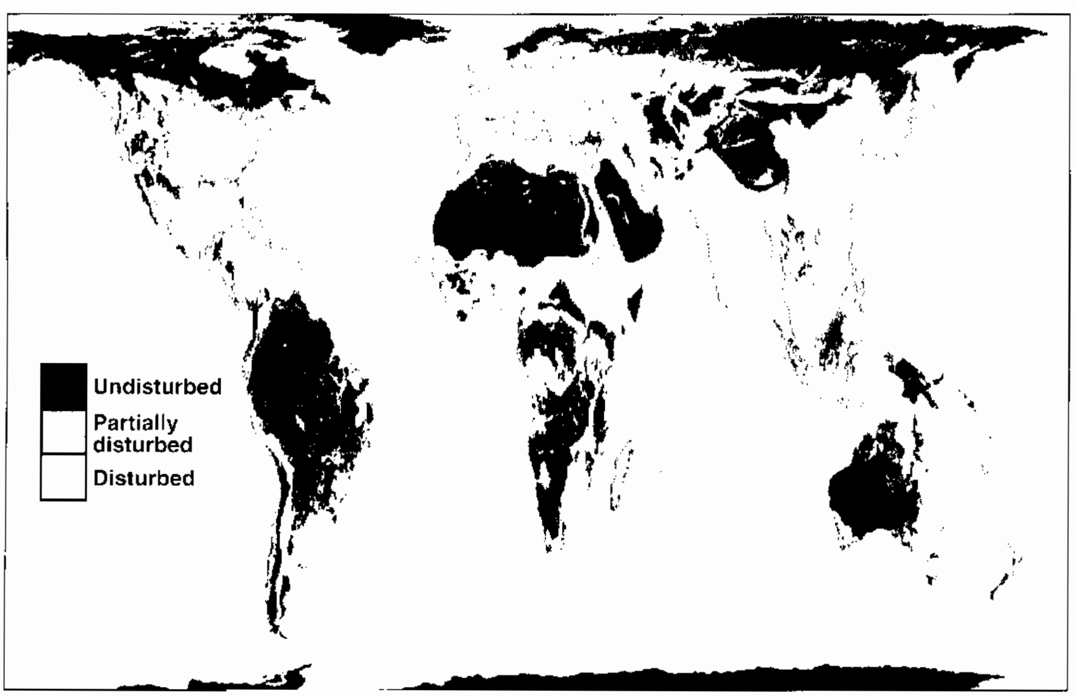


Figure 1. Human disturbance to natural vegetation. Source: Conservation International.

Table 1
Key to Global Habitat Types
Modified from Olson *et al.* 1983

Region	Number	Vegetation Type
All	**1.**	**Closed Forest and Woodland** (Figure 2a)
A,E,O	*Taiga and other conifer*	
A,E	1(a)	Main and southern taiga. Coniferous evergreen trees of the boreal climate zone, mixed toward the southern boundary with deciduous birch, poplars, and larch.
A,E,O	1(b)	Other conifer. Mostly evergreen needle-leaved trees, excluding most taiga, in both regions of persistent snow and warm to hot climes.
A,E,N,T,O	*Mid-latitude broad-leaved and mixed forest*	
A,E,N,O	1(c)	Temperate broad-leaved forest. Deciduous hardwoods, localized or no conifers.
A,E,N,T	1(d)	Mixed woods. Deciduous to evergreen broad-leaved forest, with native or planted conifers interspersed.
A,T,S,O	*Tropical/subtropical broad-leaved forest*	
A,T,S,O	1(e)	Broad-leaved humid forest. Includes both evergreen rain forest and seasonally deciduous semi-evergreen (monsoon) forest.
A,T,S,O	1(f)	Tropical dry forest and woodland. Drought-deciduous forest with many dry months alternating with rainy season (or two near equator). Drier or most burned parts often have grassy field layer, transitional to savannahs.
All	**2.**	**Open or Interrupted Woodland** (Figure 2b)
A,T,S,O	2(a)	Tropical savannah and woodland. Palms and other trees and shrubs scattered in grassy undercover, frequently burned or grazed.
A,T,S	2(b)	Tropical montane complexes. Rainy or cloud forest situated at 1,000-2,500 meters (or higher) with alpine meadow, scrub, rock interruptions; also highland crop, burn, and fallow areas.
All	2(c)	Other dry woods/scrub/grass complexes. A broad category including Mediterranean-type sclerophyllic vegetation, succulent and thorn woods and scrub, other dry or highland tree or shrub types (juniper, open pine) and quebracho forest of northern Argentina and Paraguay.
A,E	2(d)	Northern or maritime taiga. Mostly stunted and patchily distributed boreal conifer, sub-alpine.
All	2(e)	Second growth woods and field mosaics. Includes more than 40% closed forest or open woods, mostly heavily disturbed by cutting or fire, or regrowing or replanted, alternating with trees or other crops, settlements, cultivation or open areas (mainly temperate, 72% of total area). Also includes predominantly cultivated or grazed landscapes with isolated remanants of forest or more open woodland (mainly tropical, 28% of total area).

Continued on next page

Region	Number	Vegetation Type
All	**3.**	**Settled Areas: Cropped, Residential, Commercial, and Associated Marginal Lands** (Figure 2c)
T,E	3(a)	Paddyland. Rice and tropical crops, with settlements and/or tree remnants interspersed.
All	3(b)	Towns, farms, and other irrigated dryland row crops.
All	**4.**	**Grass and Shrub Complexes: Low Vegetation with Few or No Trees** (Figure 2d)
All	4(a)	Grassland or shrubland. Includes most types of shrub and grassland (prairie, pampas, steppe, puna: 81% of total area), alpine meadow (18%), and heath and moorland (1%).
E	4(b)	Cold grass or stunted woody complex. Includes Tibetan and Siberian meadows (33% of total area), and dwarf and scrub vegetation at polar and altitudinal limits of taiga or montane forest or woodland (67%).
N,E,S,A,O	**5.**	**Tundra and Desert** (Figure 2e)
E,A,N	*Very cold areas with sparse vegetation*	
E,A,N	5(a)	Tundra. Dwarf scrub, tussock, sedge and other herb patches, commonly over permafrost. Includes both classical Arctic tundra as well as sparsely vegetated high alpine areas.
E,A	5(b)	Polar desert. Bare rocks, lichens, glacier and permanent snow fields of high Arctic and Antarctica.
N,E,S,A,O	*Desert and semi-desert*	
E,A	5(c)	Cool semi-desert scrub. Tall or low shrub, semi-shrub, shrub steppe and open grassland in comparatively cool, continental climates.
N,E,S,O	5(d)	Sand desert. Bare, moving sand dunes, with sparse shrub or grass cover.
N,E,S,A	5(e)	Other desert and semi-desert. Mostly warm to hot arid shrubland and grassland, with some succulents and ephemerals.
All	**6.**	**Major Wetlands** (Figure 2f) Includes swamp/marsh, mangrove and tropical swamp woods, and bog/mire of cool or cold climates.

A = The Americas
E = Eurasia
N = North Africa/Southwest Asia
O = Oceania
S = Sub-Saharan Africa
T = Tropical Asia

Table 2
Cat Species Occurrence in Major World Habitat Types

Habitat Type[1]	Global Area (10⁶ km²)	%	Number of Species Associated[2] Str	Sig	Mar	Tot	[% of Family]
Closed and Open Forest and Woodland (1 & 2)	**58.17**	**[39.3%]**	**29**	**1**	**2**	**32**	**[89%]**
Closed Forest and Woodland (1)	**30.79**	**[20.8%]**	**19**	**8**	**5**	**32**	**[89%]**
Mostly taiga and other conifer (1a & 1b)	*10.66*	*[7.2%]*	*3*	*4*	*5*	*12*	*[33%]*
Main and southern taiga (1a)	7.16	[4.8%]	2	0	1	3	[8%]
Other conifer (1b)	3.50	[2.4%]	3	4	5	12	[33%]
Mid-lat. broad-leaved and mixed (1c & 1d)	*5.03*	*[3.4%]*	*3*	*9*	*8*	*20*	*[56%]*
Temperate broad-leaved forest (1c)	1.49	[1.0%]	0	6	6	12	[33%]
Mixed woods (1d)	3.54	[2.4%]	3	7	9	19	[53%]
*Tropical broad-leaved forest (1e & 1f)**	*15.10*	*[10.2%]*	*17*	*5*	*1*	*23*	*[64%]*
Broad-leaved humid forest (1e)**	10.38	[7.0%]	14	3	0	17	[47%]
Tropical dry forest and woodland (1f)	4.72	[3.2%]	7	9	4	20	[56%]
Open or Interrupted Woods (2)	**27.38**	**[18.5%]**	**14**	**16**	**0**	**30**	**[83%]**
Tropical savannah and woodland (2a)	7.32	[5.0%]	8	5	5	18	[50%]
Tropical montane complexes (2b)	0.60	[0.04%]	1	6	10	17	[47%]
Other dry woods/scrub/grass complexes (2c)	7.60	[5.1%]	6	10	2	18	[50%]
Northern or maritime taiga (2d)	4.35	[2.9%]	0	2	0	2	[6%]
Second growth woods and field mosaics (2e)	7.20	[4.9%]	2	15	11	28	[78%]
Settled Areas (3)	**15.90**	**[10.7%]**	**0**	**6**	**11**	**17**	**[47%]**
Paddyland (3a)	2.00	[1.4%]	0	4	1	5	[14%]
Towns, farms and other cropland (3b)	13.90	[9.4%]	0	4	12	16	[44%]
Grass and Shrub Complexes (4)	**23.90**	**[16.1%]**	**14**	**4**	**11**	**29**	**[81%]**
Grassland or shrubland (4a)	21.40	[14.5%]	14	4	10	28	[78%]
Cold grass or stunted woody complex (4b)	2.55	[1.7%]	1	0	4	5	[14%]

Continued on next page

Habitat Type[1]	Global Area (10⁶ km²)	%	Number of Species Associated[2] Str	Sig	Mar	Tot	[% of Family]
Tundra and Desert (5)	**44.40**	**[30.0%]**	**9**	**6**	**3**	**18**	**[50%]**
Very cold sparse vegetation (5a & 5b)	*26.20*	*[17.7%]*	*2*	*1*	*6*	*9*	*25%]*
Arctic tundra and barren alpine (5a)	11.00	[7.4%]	2	1	6	9	[25%]
Polar ice and desert (5b)	15.20	[10.3%]	0	0	0	0	—
Desert and semi-desert (5c, d & e)	*18.20*	*[12.3%]*	*7*	*5*	*4*	*16*	*[44%]*
Cool semi-desert scrub (5c)	2.00	[1.4%]	3	1	4	8	[22%]
Sand desert (5d)	5.20	[3.5%]	1	3	4	8	[22%]
Other desert and semi-desert (5e)	11.00	[7.4%]	4	5	4	13	[36%]
Major Wetlands (6)	**2.90**	**[2.0%]**	**6**	**1**	**7**	**14**	**[39%]**

Key:

1 See Table 1 for definition of habitat types.

2 Str=Strongly associated. Sig=Significantly associated. Mar=Marginally associated. Tot=Total. [%]=% of 36 species in the family Felidae. See Box 1 for explanation of how species-habitat associations were assigned.

* FAO (1993) estimates tropical and subtropical forest cover as 19.1 million km^2 in 1980, a refinement of its earlier estimate of 19.35 million km^2. This total differs noticeably from the 15.10 million km^2 given above for habitat types 1e & 1f, although FAO data on forest cover was a major source of information for Olson *et al.* (1983). However, on pp. 48-49, Olson *et al.* (1983) explain that total forest cover can be calculated from their data in a way closer to FAO's methodology. From habitat type 2e, Second growth woods & field mosaics, 1.7 million km^2 can be allocated to 1e, broad-leaved humid forest, and 0.6 million km^2 to 1f, tropical dry forest & woodland. The 0.6 million km^2 of 2b, tropical montane complexes can also be added to 1e. [Note: the total area covered by this habitat type is actually 1.2 million km^2, but Olson *et al.* apportion half, consisting mainly of non-woods components, to 3, settled areas.] In this way, a total coverage of 19.4 million km^2 is obtained for tropical and subtropical forest, a total which agrees closely with the FAO estimate.

** Although the following sub-categories are not mapped, Olson *et al.* (1983: p. 48) provide details on the types of humid broad-leaved forest which make up habitat type 1e.

Habitat type 1e sub-category	**Area (10⁶ km²)**
Lowland rain forest	*3.0*
Mangroves (of forest structure)	0.2
Evergreen equatorial forest	2.8
Tropical seasonal forest	*7.4*
Evergreen or deciduous "moist" forest, closed or regenerating well	6.0
Planted, degraded, poor site, or marginal "forest"	1.4
Total tropical/subtropical broad-leaved humid forest	10.4

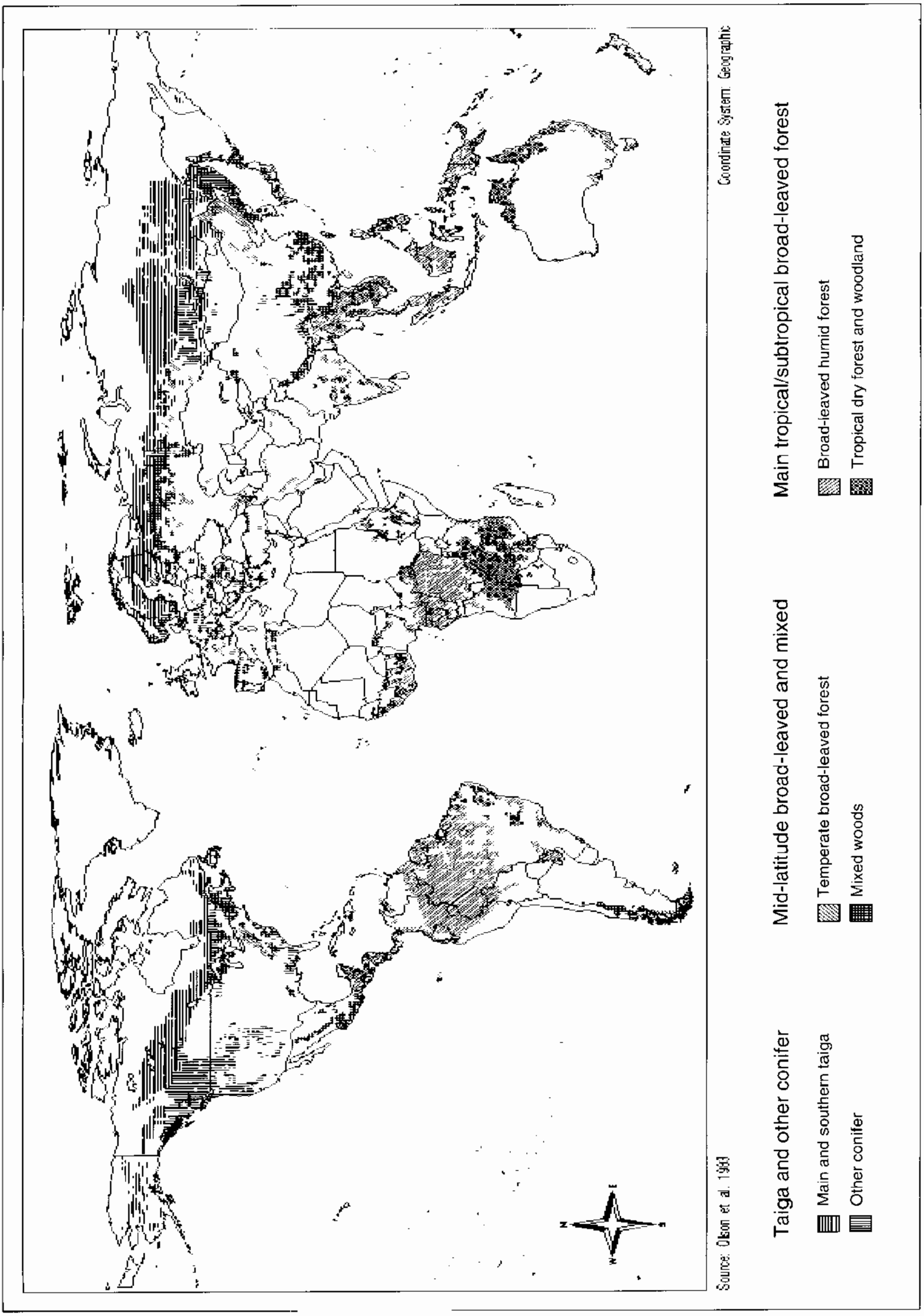


Figure 2a. Habitat map: Closed Forest and Woodland. Source: World Conservation Monitoring Centre.

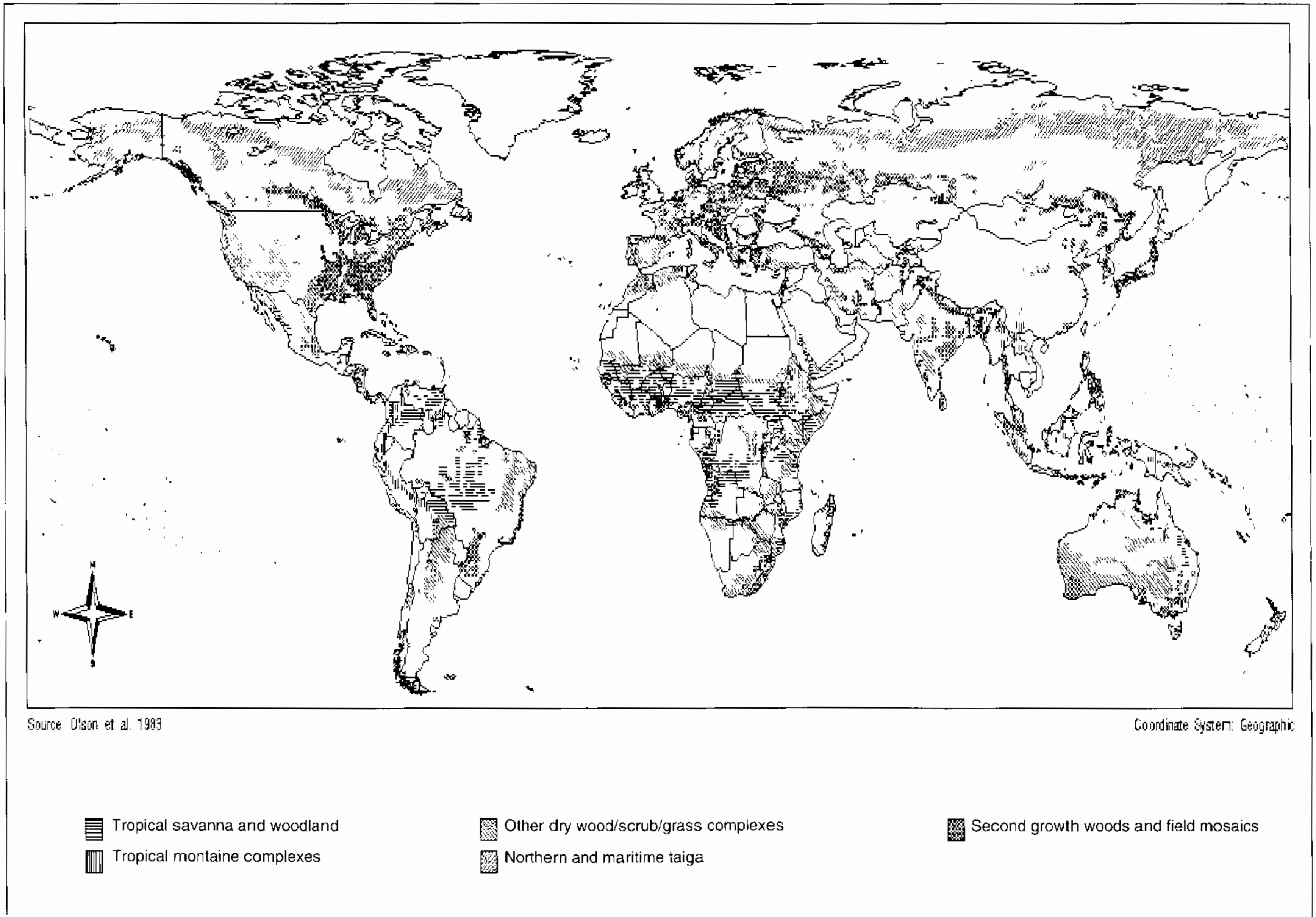
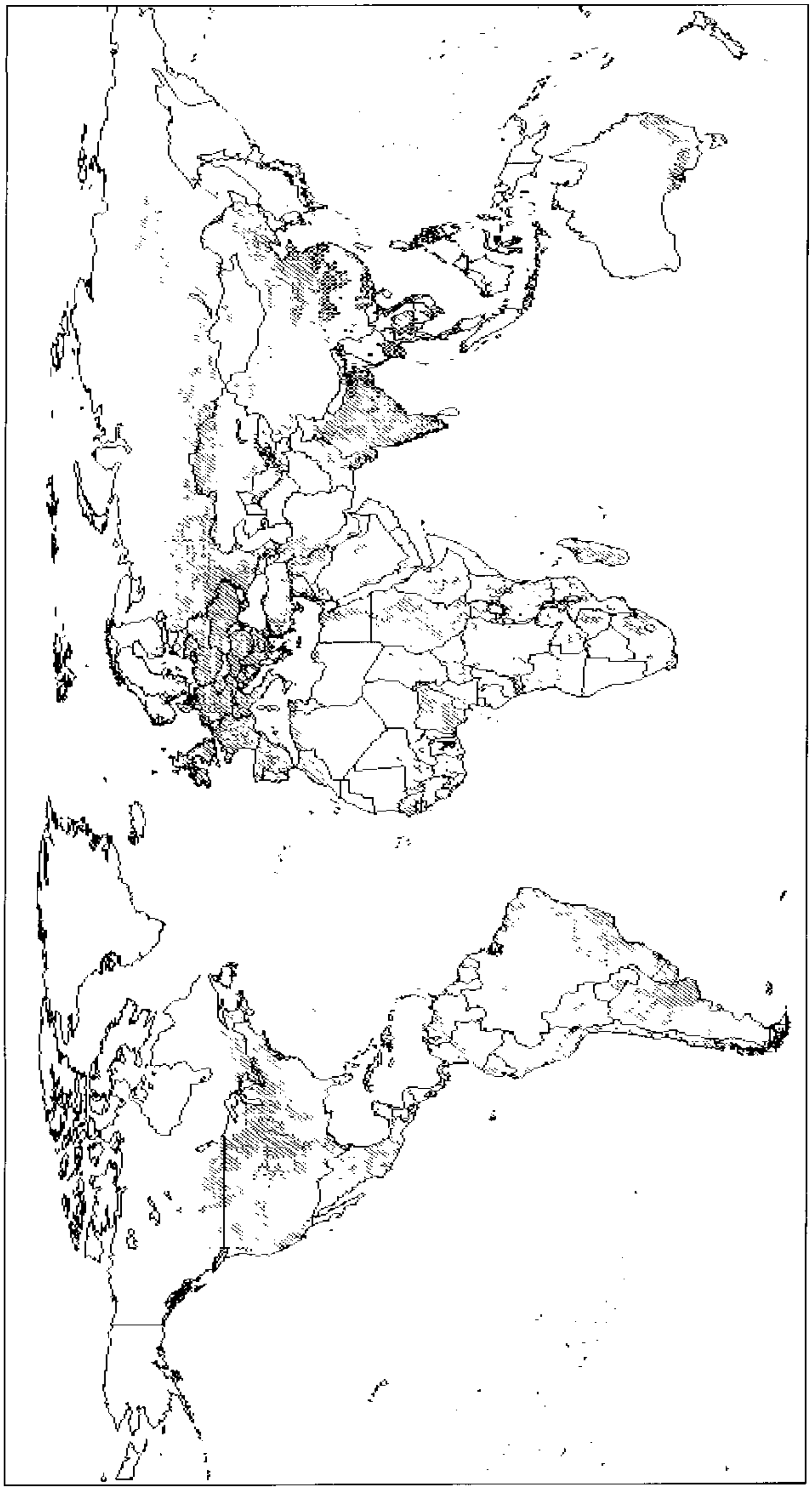


Figure 2b. Habitat map: Open or Interrupted Woodland. Source: World Conservation Monitoring Centre.



Cropped, residential, commercial and associated marginal lands

- Paddyland
- Towns, farms, and other irrigated dryland row crops

Figure 2c. Habitat map: Settled Areas. Source: World Conservation Monitoring Centre.

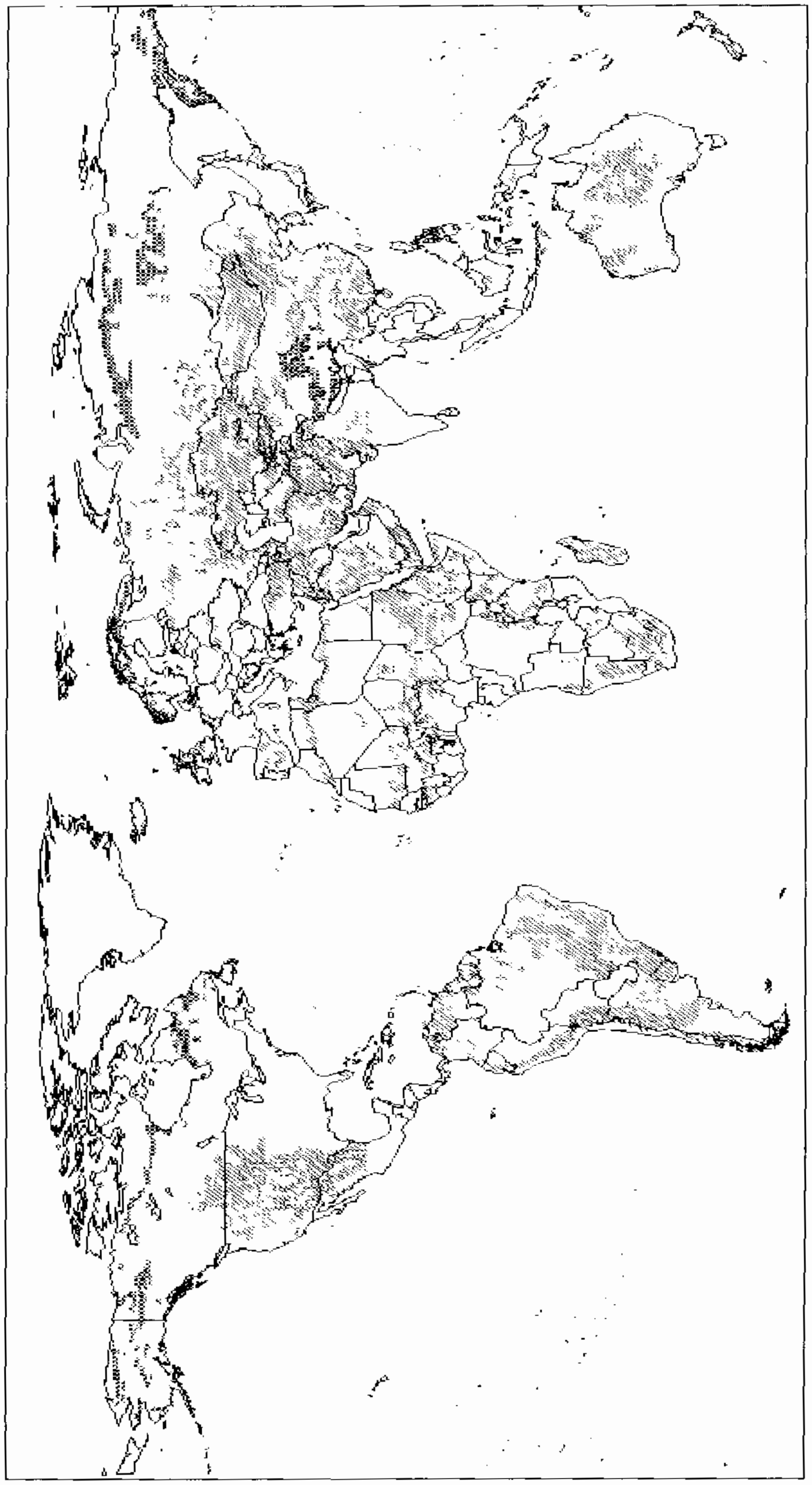


Figure 2d. Habitat map: Grass and Shrub Complexes. Source: World Conservation Monitoring Centre.

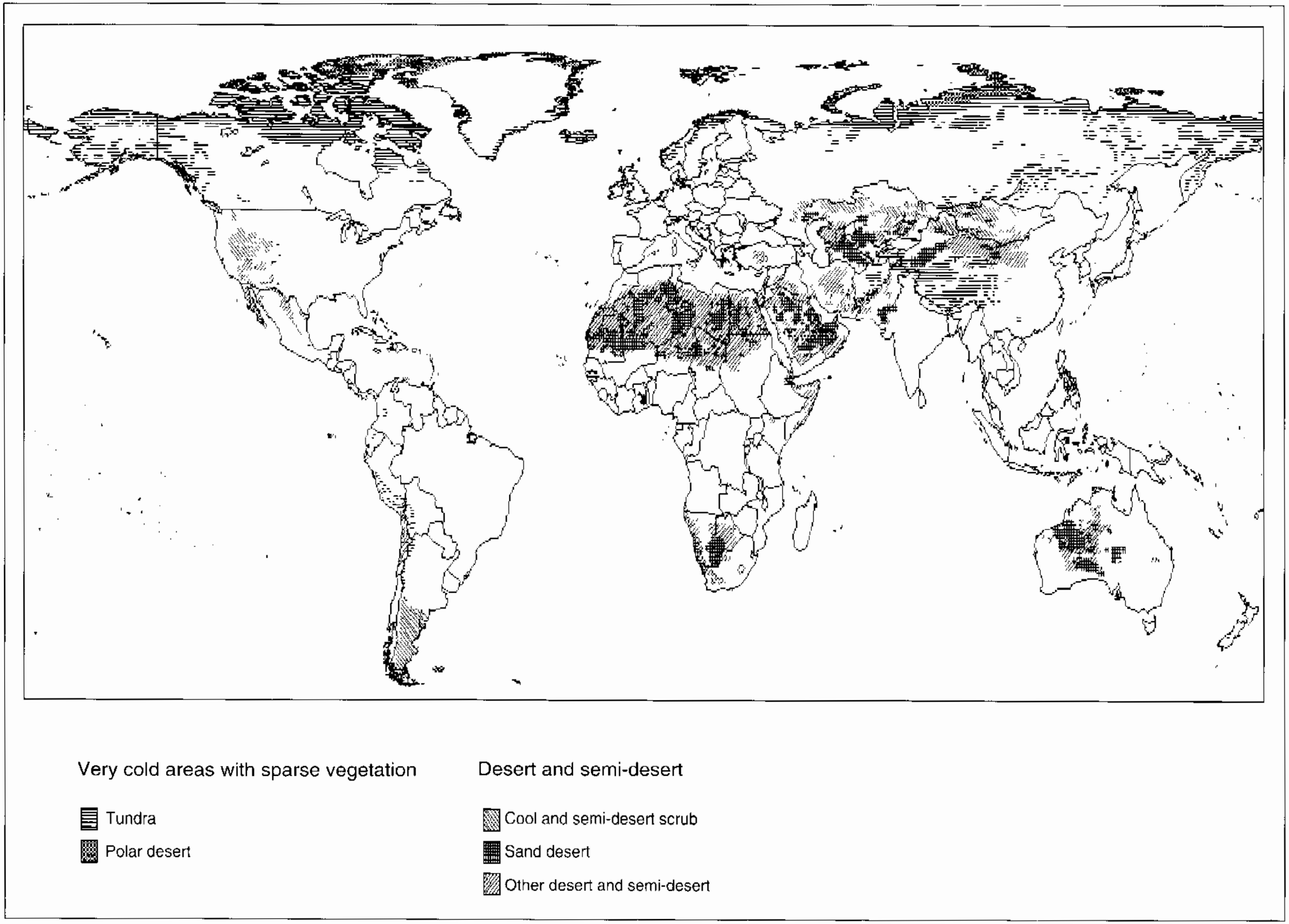


Figure 2e. Habitat map: Tundra and Desert. Source: World Conservation Monitoring Centre.

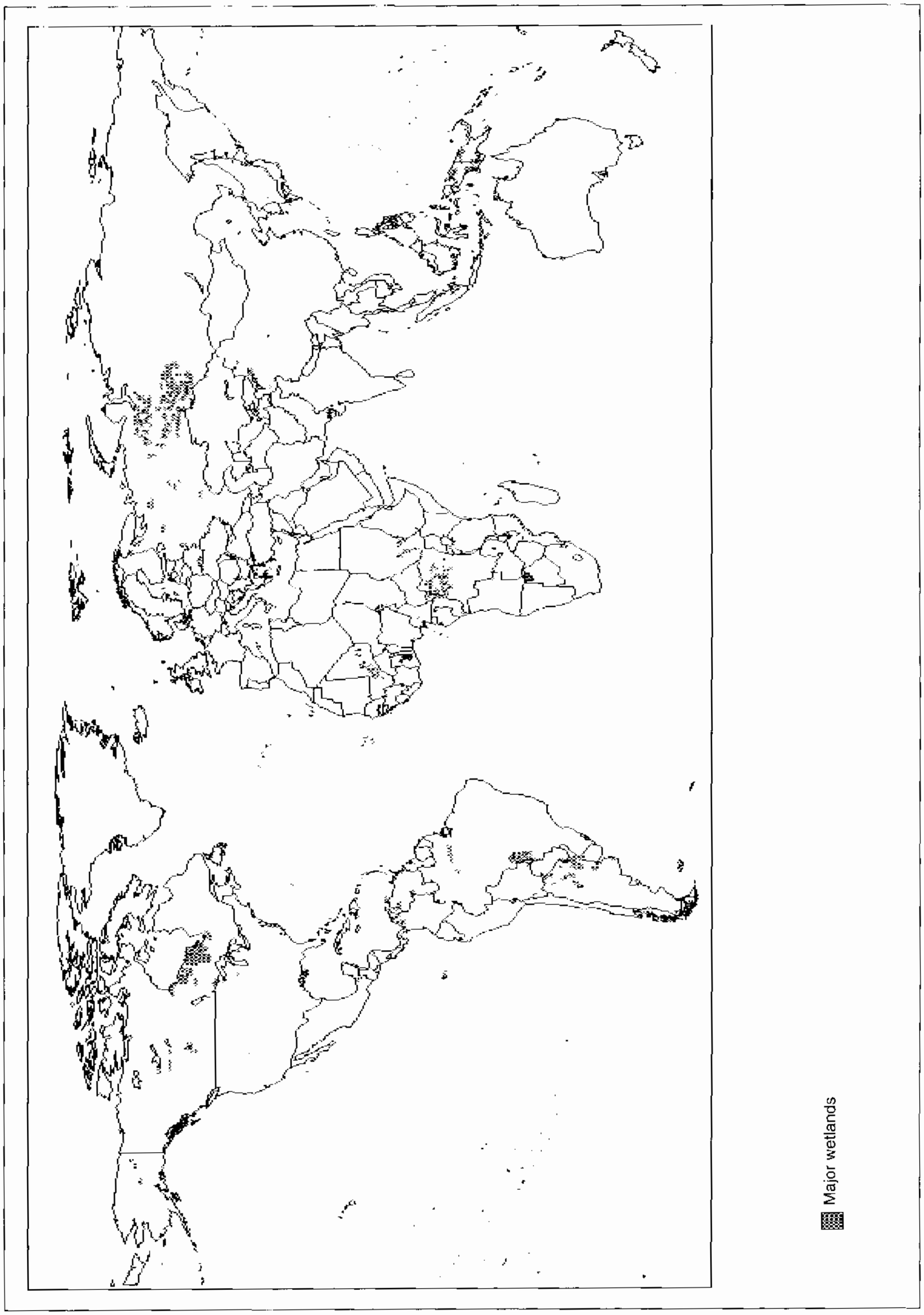


Figure 2f. Habitat map: Major Wetlands. Source: World Conservation Monitoring Centre.

Ravi Chellam

A lioness among tree stumps which were part of the Gir Forest, the last refuge of the Asiatic lion.

which are associated with tropical forest tend to be strongly associated (this tendency is much stronger for rain forest than tropical dry forest), so that tropical forest constitutes major portions of these species' ranges. Therefore, it is worth examining loss of tropical forest habitat in detail.

Tables 5 and 6 present the FAO's data on tropical deforestation by ecological zone and geographical region over the 1980s. From Table 5, it may come as a surprise, given all the attention paid to loss of rain forest in the media, that this habitat type is undergoing a lower rate of deforestation than moist deciduous, tropical dry, and montane forest. Moreover, it is the tropical forest type with the largest global area, and the type which still covers most of its original land area (76%). (The figures for the other types are somewhat deceptive. In the rain forest ecological zone close to 100% was originally forested, while in the very dry zone considerably less than 100% is likely to have been forested originally: FAO 1993). This is not to underplay the importance of tropical rain forest—the habitat type associated with the largest number of vulnerable cat species—but to highlight the significance of deforestation in other tropical zones. Loss of montane forest is especially significant for the oncilla in Latin America, and for the tropical Asian cats of the Himalayan region.

Table 6 shows the regions which have undergone the highest rates of deforestation over the past decade are continental southeast Asia, insular southeast Asia, Central America and Mexico, and west Africa. Insular southeast Asia still has over 100 million ha (1 million km^2) of forest cover. The remaining three regions have between 40-70 million ha remaining, as do other regions with lower rates of deforestation: west and east Sahelian Africa, and south Asia. Tropical South America is the region with the most remaining tropical forest cover, although comparison with its total land area still indicates that a significant portion has already been lost. Central Africa underwent the lowest rate (5.3%) of deforestation in the 1980s, and still has 200 million forested ha, although nearly half of its original forest area has been lost.

Table 7 lists the vulnerable cat species found in these regions which are strongly or significantly associated with tropical moist or dry forest. It is readily apparent that continental and insular southeast Asia, which are both undergoing very high rates of deforestation, have the largest number of species associated, and are of top global priority for habitat conservation efforts as far as cats are concerned. While cultivation and settlement play an important role, much of tropical Asia's deforestation is the result of logging. Since the 1960s, the Asia/Pacific region has far outstripped Africa and Latin America in its average annual production of raw tropical roundwood. For example, in 1990, production was close to 120 million cubic meters, while Africa and Latin America each produced only around 20 million cubic meters (FAO 1993).

What is happening to all the other types of habitat with which cats are associated? There is little published data. Fortunately, it is possible to undertake a preliminary evaluation with regard to the habitat types of Olson *et al.* (1983), the foundation of the cat species vulnerability

Table 3
Habitat Specialists: Cats Associated With Six or Fewer Habitat Types

Species	Vulnerability Ranking Cat.
Iberian lynx, *L. pardinus*	1
Bornean bay cat, *C. badia*	2
Chinese mountain cat, *F. bieti*	2
Black-footed cat, *F. nigripes*	2
Kodkod, *O. guigna*	2
Andean mountain cat, *O. jacobitus*	2
Flat-headed cat, *P. planiceps*	2
Fishing cat, *P. viverrinus*	2
Oncilla, *L. tigrinus*	3
African golden cat, *P. aurata*	3
Marbled cat, *P. marmorata*	3
Sand cat, *F. margarita*	4
Margay, *L. wiedi*	4
Manul, *O. manul*	4

ranking system used here. Using a variety of literature sources, and making extensive use of newly available remote sensing imagery, J. Watts of the U.S. Dept. of Energy's Oak Ridge National Laboratory has updated the computer database (in 1990 and 1992) that forms the basis of the habitat maps of Olson *et al.* (1983) (Figs. 2a-f). Due to lack of funds, the update was not comprehensive and has currently ground to a halt. Quantitative data is only available for major groupings, rather than individual habitat types (Table 8). For selected individual habitat types, J. Watts (pers. comm. 1994) was able only to indicate qualitatively whether the global area has increased, decreased, or remained the same since 1980 (Table 4).

Table 8 shows that both closed and open forests and woodland have decreased in global area over the past decade. Most cat species are associated with forest, and thus most cats have lost a portion of their range. Watts' figures indicate that tropical and subtropical broad-leaved humid and dry forest has declined by 6% (± 3%); the FAO's (1993) figures indicate that 8% is more appropriate. The habitat type which has shown the greatest increase over the 1980s (5% ± 4%) is (3) settled areas. While nearly

Table 4
Key Habitat Types for Vulnerable Cat Species

	Habitat type	Global area in 1980* (10^6 km²)	Trend over the 1980s[1]	Number of Species Str-Sig Associated: Cat. 1-3	Total
1e	Tropical moist forest	10.38	D	10 [53%]	17 [47%]
1f	Tropical dry forest	4.72	D	7 [37%]	17 [47%]
4a	Grassland or shrubland	21.40	I	7 [37%]	18 [50%]
2b	Tropical montane complexes	0.60	D[a]	6 [32%]	7 [19%]
2e	Second-growth woods/fields	7.20	I	6 [32%]	17 [47%]
2a	Tropical savannah and woodland	7.32	I	5 [26%]	13 [36%]
2c	Other dry woods/scrub/grass	7.60	S	5 [26%]	16 [44%]
6	Major wetlands	2.90	D	5 [26%]	7 [19%]
1d	Mixed woods	3.54	D[b]	4 [21%]	10 [28%]
5a	High alpine and tundra	2.73	I[b]	3 [16%]	3 [08%]
5e	Other desert and semi-desert	11.00	I	3 [16%]	9 [25%]

* Olson *et al.* 1983

[1] D = Decreasing; S = Stayed the same; I = Increasing. Data from J. Watts, U.S. Dept. of Energy, Oak Ridge National Laboratory, Tennessee (pers. comm. 1994).

[a] The tropical montane forest component of this habitat type decreased, while the highland crop, burn and fallow area component increased.

[b] Change very slight; could reflect an improved estimate of total area rather than actual growth or decrease.

half of the species in the family Felidae are associated with such areas, the degree of association is generally marginal (Table 2). The only change in habitat area which could be interpreted as good news for cats is the increase (4% ± 2%) in habitat type 4, grass and shrub complexes, with which a majority of both vulnerable species and the cat family as a whole are associated. The cheetah is the best example of a species which could strongly benefit from this change. However, this increase in grass- and shrubland has largely been brought about by deforestation, and intensive human modification is implicit. Under such circumstances, cats may not necessarily survive the transition (see discussion below on the factors which affect the survival of cats in modified habitats).

Of the 11 habitat types which harbor the greatest numbers of vulnerable cat species, five have declined in area over the 1980s, five have increased, and one is essentially unchanged (Table 4).

Special mention should be made of the fact that statistics from some countries seem to indicate that forest growth and regeneration are outpacing deforestation. However, this generally represents large-scale monoculture forest plantations. Most plantations are in the temperate regions (especially Russia, China, the U.S., Japan, and Europe). However, tropical plantation area has been rapidly expanding in recent years (Lanly 1982, Evans 1982, 1986, Mather 1990). Evans (1986) estimated the total area of forest plantations worldwide in the early to mid-1980s to be between 1.2-1.4 million km^2, or about 4% of closed forest area (Olson *et al.* 1983).

In tropical Asia, plantations of oil palm and rubber trees are particularly significant. In Indonesia, industrial tree plantations are likely to be the major cause of forest conversion in coming decades (Collins *et al.* 1991). Malaysia is currently the top producer and exporter of palm oil and rubber in the world. Most of the production takes place in Peninsular Malaysia, where over 31,000 km^2 of lowland forest has been converted to industrial plantations—about one-quarter of the original forest cover (Collins *et al.* 1991). Most tropical industrial forest plantations, however, are not converted from forests but from savannah grasslands (which may have earlier been wooded, and

Table 5
Estimates of Tropical Forest Area (in millions of km^2) and Deforestation by Ecological Zone (FAO 1993)

Ecological Zone	Land Area (10^6 km^2)	Population		Forest Cover (1990)		Deforestation (1981-1990)	
		Density (inhabitants /km^2)	Growth (% per year)	Area	% Land Area	Area	% Forest Cover
Forest Zone	**41.86**	**57**	**2.4**	**17.48**	**42**	**1.53**	**8**
Lowland formations	*34.86*	*57*	*2.3*	*15.44*	*44*	*1.28*	*8*
Rain forest	9.47	41	2.2	7.18	76	0.46	6
Moist deciduous	12.89	55	2.4	5.87	46	0.61	10
Dry and very dry	12.49	70	2.3	2.38	19	0.22	9
Upland formations (Hill and mountain forest)	*7.01*	*56*	*2.6*	*2.04*	*29*	*0.25*	*11*
Non-Forest Zone (Alpine Areas, Deserts)	**5.92**	**15**	**3.1**	**0.08**	**01**	**0.01**	**10**
Total Tropics	**47.78**	**52**	**2.4**	**17.56**	**37**	**1.54**	**8**

Totals may not tally due to rounding.

Table 6
Estimates of Tropical Forest Area (in millions of hectares[1]) and Deforestation by Geographic Sub-region (FAO 1993)

Geographic Sub-region/Region	Number of Countries	Land Area (10^6 km^2)	Forest Cover (10 ha^2) 1980	1990	Deforestation (1981-1990) Area	Percent
Africa	**40**	**2,236.1**	**568.6**	**527.6**	**41.0**	**7.2**
West Sahelian Africa	6	528.0	43.7	40.8	2.9	6.6
East Sahelian Africa	9	489.7	71.4	65.5	5.9	8.3
West Africa	8	203.8	61.5	55.6	5.9	9.6
Central Africa	6	398.3	215.5	204.1	11.4	5.3
Tropical Southern Africa	10	558.1	159.3	145.9	13.4	8.4
Insular Africa	1	58.2	17.1	15.8	1.3	7.6
Asia and Pacific	**17**	**892.1**	**349.6**	**310.6**	**39.0**	**11.2**
South Asia	6	412.2	69.4	63.9	5.5	7.9
Continental Southeast Asia	5	190.2	88.4	75.2	13.2	14.9
Insular Southeast Asia	5	244.4	154.7	135.4	19.3	12.5
Pacific	1	45.3	37.1	36.0	1.1	2.9
Latin America and Caribbean	**33**	**1,650.1**	**992.2**	**918.1**	**74.1**	**7.5**
Central America and Mexico	7	239.6	79.2	68.1	11.1	14.0
Tropical South America	7	1,341.6	864.6	802.9	61.7	7.1
Caribbean	19	69.0	48.3	47.1	1.2	2.5
Total	**90**	**4,778.3**	**1,910.4**	**1,756.3**	**154.1**	**8.1**

[1] To convert hectares to km^2, multiply by .01

cleared for agriculture and grazing) (Mather 1990).

Forest plantations are characterized by high timber productivity compared with natural forest in similar environments. In Latin America, industrial plantations make up less than 1% of the forest area, but account for 30% of timber production. The proportion is predicted to rise to 50% by 2000 (Evans 1986). Industrial plantations can employ a large number of people on small areas of land and thus relieve pressure on natural forests (Sayer *et al.* 1992). However, forest plantations are also characterized by low biodiversity (Sawyer 1993) and, in some temperate zone countries (especially in Europe), industrial managed forests have largely replaced natural forests (WCMC 1992).

The evidence on cats' ability to make use of monoculture plantations is scanty and somewhat contradictory (see discussion below). It is a subject deserving of further research. Sawyer (1993:45) makes several general recommendations for plantation management to encourage wildlife "opportunities" in industrial plantations. One measure—allowing an understory to develop for cover and food for terrestrial herbivores—is specifically mentioned as having benefitted the tiger in teak plantations in India (P. Jackson, pers. comm.).

Finally, statistics on habitat loss do not necessarily include habitat degradation resulting from over-exploitation, such as over-grazing of grasslands. Degraded soils result in a loss of vegetative productivity. This adversely affects cats in two ways: (1) poor quality vegetation supports a lower density herbivore prey base; and (2) loss of vegetative cover reduces habitat suitability. According to a UNEP-sponsored study of human-caused soil degradation over the past 45 years (Oldeman *et al.* 1990), about

Table 7
Vulnerable Cat Species Strongly or Significantly Associated with Tropical Moist and Dry Forest

Region(s)	Species
Africa	
Sahelian and West Africa	Cheetah[a], leopard[b], lion
West and Central Africa	African golden cat
Tropical Southern Africa	Lion
Asia and Pacific	
South Asia[c]	Tiger, fishing cat, rusty-spotted cat
Continental and Insular Southeast Asia	Tiger, Bornean bay cat (Ins. only), flat-headed cat, Clouded leopard, marbled cat, Asiatic golden cat, Fishing cat
Latin America and Caribbean	
Mexico, Central America, and Tropical South America	Jaguar, oncilla, margay[d]

[a] The cheetah is only marginally associated with tropical dry forest in general, but this association is stronger in the Sahel than elsewhere in Africa.

[b] The leopard is included here because of its virtual extirpation from the Sahel (see Species Account); tropical dry forest is a significant refuge for it in this region.

[c] Only those species with large or significant (e.g. fishing cat in southwestern India) portions of their range in South Asia are included.

[d] The margay is Category 4, but is a habitat specialist strongly associated with tropical moist forest.

10% (12.15 million km^2) of the globe's vegetated land area (115 million km^2) has suffered moderate to severe soil degradation at human hands. Most of this degradation is in the moderate category; some of the soil's ability to process nutrients into a form usable by plants has been destroyed, and only with major improvements—beyond the resources of the average farmer—can full productivity be restored. Severely degraded soils are very expensive to restore and are usually abandoned.

Soil degradation is most advanced in Africa and Asia. In Africa, habitat degradation has resulted primarily from overgrazing by livestock, with the most affected areas in arid and semi-arid lands in the southern, eastern, and Sahel regions. These regions harbor about 55% of Africa's 550 million head of livestock, and stock numbers have increased by 75% from 1950 to 1985, in spite of the severe droughts that occurred in most African arid zones in the early 1970s and 1980s (Le Houérou and Gillet 1986). In tropical Asia, soil degradation arises mainly from deforestation, which causes most soil degradation in South America as well, although not as much land has been affected as in Asia. The Argentinian pampas grasslands show medium to high soil erosion from over-grazing and wind, and the western slopes of the Andes show medium to high soil erosion from deforestation and water run-off. In Central and North America, unsuitable agricultural practices account for most soil degradation. In Central America, only the Yucatan peninsula and the Darien Gap have escaped the widespread loss of vegetative productivity.

Habitat Fragmentation

In general, loss of habitat produces a decline in species total population size, and fragmentation of habitat can isolate small sub-populations from each other. As discussed later in this chapter and also in Chapter 3, small discrete populations are vulnerable to extinction due to unpredictable environmental, demographic and genetic factors, such as the deleterious effects of inbreeding depression.

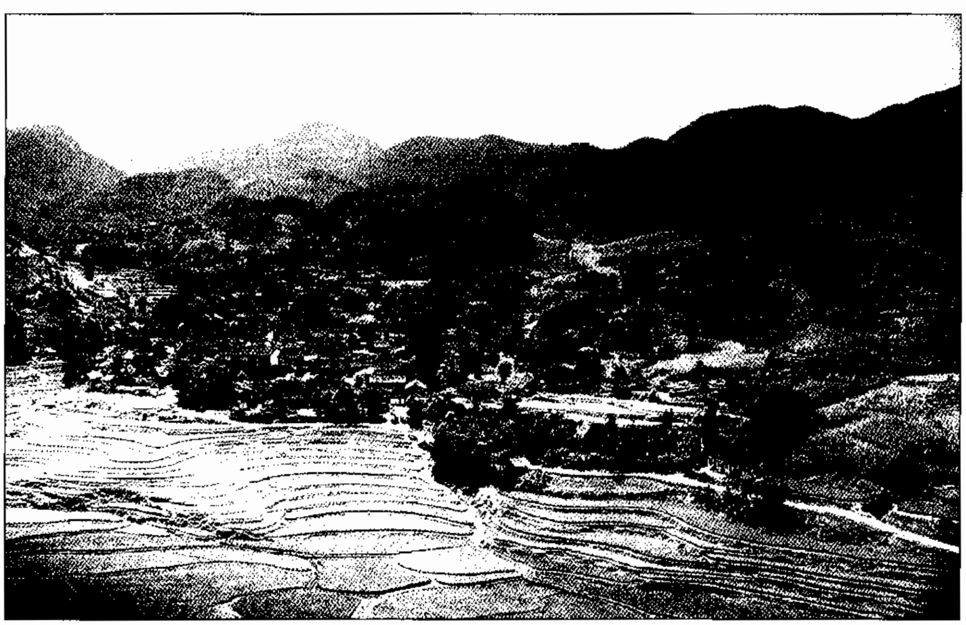
Even if good quality habitat patches are within migration distance of relatively wide-ranging species such as the cats, the intervening altered habitat can pose substantial barriers to dispersal. Asphalt roads on which vehicles can travel at speed, for example, have been shown to be a major cause of mortality for small populations of cats living in fragmented habitat (e.g., Iberian lynx [Delibes 1989] and the Florida panther [Maehr *et al.* 1991a]). S. Yasuma (*in litt.* 1992) has even documented several instances of clouded leopards killed on dirt logging roads in Kalimantan.

Global trends in habitat loss have been presented above, and an indication of the resulting degree of fragmentation is offered by McCloskey and Spalding's (1989) inventory of the world's remaining wilderness area. McCloskey and Spalding (1989) defined wilderness as relatively large tracts of land (minimum 4,000 km^2) free of human development, defined as man-made installations, including settlements, roads, buildings, airports, railroads, pipelines, power lines, and reservoirs. The presence or absence of human development was gauged from aeronautical maps for pilots, which tend to show installations in remote areas to aid navigation. Although the presence of such installations does not necessarily fragment habitat or cat populations, the methodology is more appropriate to depicting the global state of habitat fragmentation than that used by Olson *et al.* (1983), which tends to minimize fragmentation by assigning 3,000 km^2 blocks of land to a predominating habitat type. Not surprisingly, McCloskey and Spalding (1989) found that the world's habitats are substantially more fragmented than Figs. 2a-f would indicate. While one-third of the global land surface is still wilderness, 41% of it is in the Arctic or Antarctic.

Data from McCloskey and Spalding (1989) have been modified the better to reflect non-fragmented habitat available to cats. Antarctica, Oceania, Greenland, and Iceland were eliminated from the globe, as were several other countries where wild cats are not found, or occur in just a small portion. The countries where cats are found were assigned to the geopolitical regions used in this Action Plan for the species accounts. The results are presented in Table 9 simply in the form of percentages to give an idea of regional distribution of large wilderness areas.

Analysis of the data shows that 43% of the world's wilderness (which totals just over 30 million km^2) available to cats occurs in the northern regions of just two countries—Russia and Canada. Only two species, both lynxes, occur in these areas, and then only partially, with the northern limit of their ranges around the 65° N latitude.

The other major wild habitat type (20% of total wilderness) consists of the sand and semi-deserts of Asia and north Africa. Deserts support more cat species than the northern boreal forests (Table 2). However, the wilderness criteria are weak when applied to the Sahara, which makes up the bulk of this wilderness type. The region has very few permanent installations but supports some 30 million people (Le Houérou and Gillet 1986). Antelope are practically extinct in the Sahara outside reserves (East 1992a); the lion has been eradicated, the leopard practically so, and only a few small populations of cheetah persist.



Peter Jackson

Former habitat of the South China tiger in Sichuan, now intensely cultivated.

Table 8
Percentage Change in Global Area of Major World Habitat Types Since 1980*

Habitat Type	Global Area in 1980 (10^6 km^2)	Percentage Change	No. of Species Associated Cat. 1-3	Total
Closed forest and woodland (1)	30.79	8% ± 3% Decrease	16 [84%]	32 [89%]
Mostly taiga and other conifer (1a & 1b)	10.66	Slight Increase	5 [26%]	12 [33%]
Mid-latitude broad-leaved and mixed forest (1c & 1d)	5.03	5% ± 3% Decrease	6 [32%]	20 [56%]
Tropical/subtropical broad-leaved forest (1e & 1f)	15.10	6% ± 3% Decrease	13 [68%]	23 [64%]
Open or interrupted woodland (2)	27.38	4% ± 3% Decrease[1]	15 [79%]	30 [83%]
Settled areas (3)	15.90	5% ± 4% Increase	3 [16%]	17 [47%]
Grass and shrub complexes (4)	23.90	4% ± 2% Increase	13 [68%]	29 [81%]
Very cold areas with sparse vegetation (5a & 5b)	26.20	< 1% Increase	3 [16%]	9 [25%]
Desert and semi-desert (5c-5e)	18.20	2% ± 1% Increase	5 [26%]	16 [44%]
Major wetlands (6)	2.90	< 1% Decrease	7 [37%]	14 [39%]

[1] Mainly decrease, but 2e (second growth woods and field mosaics) has increased slightly.

* J. Watts, U.S. Dept. of Energy, Oak Ridge National Laboratory (pers. comm. 1994).

The most species-rich geopolitical region for cats—tropical Asia, which covers major portions of the ranges of 11 species—occupies only about 6% of the world's land area; is home to more than 60% of its people; and contains less than 1% of its wilderness. It is also the region undergoing the highest rate of tropical deforestation (Table 5). In sharp contrast to the other regions of the world, only 3% of tropical Asia consists of large tracts of undeveloped land. However, it is apparent that human population densities in this highly diverse region are such that there are essentially no large secure refuges insulated from human activity as are found elsewhere in the world. In several countries—Bangladesh, Cambodia, Vietnam—McCloskey and Spalding (1989) indicate that no "wilderness" exists at all. While a major portion of the region appears as forest in Figure 2a, McCloskey and Spalding (1989) show that it is quite fragmented. Although there are still blocks of wild habitat remaining, none of them are very large.

With regard to geopolitical sub-regions, habitat fragmentation is more advanced in Europe than anywhere else in the world: 19 out of 22 countries have no wilderness, including Spain and Portugal, home to the most endangered species of cat, the Iberian lynx. Central and South

America, the second most species-rich sub-region, with 10 cats, is much better off: the average national percentage of wilderness area is relatively high at 15%, although over half of the region's wilderness in found in Brazil. Overall, 60% of the 120 countries included in the data set have < 5% of their land area as wilderness.

Implications for Cat Species

It is difficult to discuss the implications of habitat loss and fragmentation for cats with a great deal of confidence because very few studies have specifically addressed the subject. For one thing, the mechanisms by which animals select habitats (e.g., hereditary vs. learned) is a neglected area of ecology (Krebs 1985) and, moreover, there has been little research on cats in altered environments. What may be appropriate for the few species that have been studied may not be valid for others, and any generalizations made must be qualified by drawing attention to this lack of focused research. Most research has been, and is still, carried out in protected areas, and information on species occurrence in altered habitats consists mainly of fortuitous sightings or anecdotal reports.

Few studies have focused rigorously on a comparison of the ecology, behavior or population dynamics of cats in altered habitat with undisturbed habitat, with the notable exception of Van Dyke *et al.* (1986a) on the behavior and movements of a population of pumas living around an Arizona timber concession. Other less thorough, but still important, studies include Rabinowitz (1986) on jaguars in a forested reserve in Belize surrounded by cattle ranches; Seidensticker *et al.* (1990) on leopards at the edge of Nepal's Royal Chitwan National Park; Palomares *et al.* (1991) on the micro-distribution of Iberian lynx in Spain's Doñana National Park and surroundings; Maehr *et al.* (1991b) on the movements of pumas in Florida; and Zheltuchin's (1992) observations on Eurasian lynx density in logged vs. unlogged areas in Russia.

A few studies have been conducted entirely within disturbed or modified habitat: Bowland's (1990) study of servals on farmland in South Africa; studies of leopards on a mixed livestock/game ranch in Kenya (Mizutani 1993) and in a mountainous farming region in South Africa (Norton and Lawson 1985); and studies of jaguars on cattle ranches in Brazil (Schaller and Crawshaw 1980, Crawshaw and

Table 9
Wilderness Area by Geopolitical Region

Region	Percentage of Total World Land Area[1]	Percentage of Total World Wilderness Area	Percentage Wilderness of Regional Land Area	Percentage Wilderness of National Land Area[2]
Sub-Saharan Africa	19%	18%	25%	16%
North Africa and Southwest Asia	10%	11%	31%	14%
Tropical Asia	6%	0.6%	3%	2%
Eurasia	32%	31%	26%	5%
Americas	32%	40%	33%	17%

[1] Total world land area considered as just over 120 million km^2.

[2] Average of the wilderness area percentages for each country in the region. Sub-Saharan Africa: n=40 countries; North Africa and Southwest Asia: n=19 countries; Tropical Asia: n=10 countries; Eurasia: n=28 countries; Americas: n=23 countries.

Note: Data from McCloskey and Spalding (1989) have been modified the better to reflect non-fragmented habitat available to cats. Antarctica, Oceania, Greenland, and Iceland were eliminated from the globe, as were several other countries where wild cats are not found, or occur in just a small portion.

Quigley 1991). Others have examined the diets of big cats near livestock ranches; the findings of these studies are addressed in the next chapter.

Although habitat loss is often described as the primary threat to cat populations, there are several indications that cats adjust relatively well to many forms of habitat loss and fragmentation, including deforestation, with only extremes such as urban settlement being generally devoid of cats.

Most cats make use of a variety of habitats, and this not only buffers them against the loss of a preferred habitat type, but also suggests substantial flexibility in habitat selection and use. Based on studies of the bigger cats, Sunquist and Sunquist (1989) concluded that suitability of habitat for the bigger cats is determined primarily by availability of adequate amounts of cover and prey; availability of adequate water could also be added. The index of species-habitat association used here agrees: cats occur in an average of 7.5 broadly defined habitat types. The generalist label does not include the entire family: 39% of the cat species were identified as having narrow habitat selectivity (Table 3). However, species identified as having intermediate to broad selectivity are among the better studied, while of those identified as specialists, only for one species, the Iberian lynx (with the smallest contemporary range of any cat species), has habitat association been investigated specifically (Palomares *et al.* 1991). There have been reports of some of these specialist species (kodkod, flat-headed cat, marbled cat) occurring in human-altered environments, including farms, forest plantations, and logged forest (see Species Accounts).

At the same time, cats exhibit flexibility by behaving differently in disturbed and undisturbed habitats. Pumas tend to be inactive during the middle of the day, more active during some mid-evening hours and sunset, and most active at or just prior to sunrise (Ackerman 1982, Van Dyke 1983). Van Dyke *et al.* (1986a) found that pumas in the vicinity of logging concessions and human disturbance shifted activity peaks to after sunset, concentrated other activity during night hours, and were inactive rather than active at sunrise. This pattern held true both between different pumas living in disturbed and undisturbed habitats, and for the same individual whose home range included both types of area. Others have reached similar conclusions on the basis of more anecdotal evidence. Geertsema (1985) reported that servals are almost entirely nocturnal (rather than crepuscular) in areas of high human activity, even though some of their main rodent prey are predominantly diurnal, and prey densities can be quite high around agricultural areas (Smithers 1978). In Sumatra, Griffiths and van Schaik (1993a) similarly reported that tigers in Gunung Leuser National Park were primarily diurnal or crepuscular, but almost exclusively nocturnal close to human settlement. Tigers were long considered to be primarily nocturnal or crepuscular in India, but after they were strictly protected in some reserves, such as Ranthambhore National Park, daylight activity was frequently observed (Thapar 1992).

Some degree of habitat fragmentation is demonstrably beneficial to cats. The two habitat types with the most cat species associated (28 species) are both fragmented habitat types: 2e, second growth woods and field mosaics, and 4a, grass and shrubland (Table 2). These two types of habitat often arise from human activities. A mosaic of trees or shrubs and grassy vegetation may be ideal for most cats. This is related to the fact that edge environments are good for hunting (e.g., Eaton 1970, Sunquist 1981, Prins and Iason 1989), for two reasons: (1) clearings and forest gaps are good habitat for both small and large herbivorous prey species, primary productivity being greater than in closed forest (e.g., Leopold 1933) and; (2) cats mainly hunt by sight, and an edge environment gives a cat cover to hide in and a view over which to spot prey. Two North American cats for which habitat use has been well studied--the Canada lynx (intermediate habitat selectivity) and bobcat (broad habitat selectivity)—have been found to hunt mainly in forest clearings made by fire, logging, farms, and roads (Hall and Newsom 1978, Miller 1980, Parker 1981).

Panwar (1987) and McNeely (1994) have pointed out that traditional systems of shifting cultivation, which have existed for over 10,000 years in tropical Asia, make for good habitat which supports a high diversity of wildlife. Large ungulates feed in the abandoned fields, providing prey for the bigger cats. Older fields contain a high proportion of fruit trees on which a variety of smaller arboreal animals and birds come to feed, providing prey for the smaller cats. Closed forest patches provide the cats with shelter. Wharton (1968) has provided strong evidence that the distribution of the major large mammals of southeast Asia is highly dependent on shifting cultivation, because mature tropical forests conceal most of their edible products high in the canopy beyond the reach of terrestrial herbivores, while clearings bring the forest's productivity down to where it can be reached. Karanth and Sunquist (1992) reached a similar conclusion regarding the density of herbivores in mixed habitats, noting that maintenance of clearings with successional vegetation within the tropical forest of southwestern India's Nagarhole National Park was at least partly responsible for high herbivore biomass, of an order comparable to or higher than that found in African savannah parks. Nagarhole also supports relatively high tiger densities (Karanth 1991).

Modified habitats that are considerably less optimal than tree and grass mosaics can still be used. Pumas were only rarely located in or moved through clear-cut logged areas in Arizona, but one female established a home range which included such an area. Although she used both the logged area and other less disturbed areas, the logged area was seldom visited during periods of human activity (Van Dyke *et al.* 1986a). Van Dyke *et al.* (1986a) attributed the reluctance of pumas to use logged areas primarily to loss of cover, while pointing out that increased human activity and road density were also deterrents.

Johns (1986, 1989, 1992) has examined the effects of tropical forest logging on wildlife, and has concluded that "few predators are eliminated by logging operations in rain forest" (Johns 1992:45). In the tropics, logging is usually not as destructive as in the temperate zone. While damage associated with the "selective" harvesting of commercially valuable species can leave up to 30-40% of a concession bare of vegetation (Kartawinata 1978), this compares favorably with the results of temperate zone clear-cutting as practiced in the Arizona study area referred to earlier. In general, Johns (1989) suggests that few mammals are specialized exclusively for mature forest vegetation. Tree falls and fires create both small and large gaps in forests, and subsequent secondary regeneration is an essential part of forest cycles (Pickett *et al.* 1992). Johns (1989) recorded both clouded leopard and marbled cat in six-year-old logged forest in Sabah, and small cats (unidentified) were seen in logged forest in Peninsular Malaysia every year from one to 12 years after logging. While admitting the difficulty of sorting out whether species occur in logged areas only due to availability of unlogged blocks, isolates, or riverine refuges, Johns (1989:74) speculates that "large predators, such as clouded leopards...may be able to persist solely within logged forest if the area is large enough." However, in Peninsular Malaysia, he found that tigers and leopards were largely absent even from older logged forest, despite the availability of prey species—including deer, mouse deer, and seladang or gaur—which were attracted to the grasses and regenerating growth. He concludes that their absence was probably due directly to persecution from hunters subsequent to the lifting of access restrictions by the logging company.

Sunquist and Sunquist's (1989) characterization of habitat suitability mentioned above can also be stated in this way: the only type of habitats not suitable for cats are those which have inadequate or unsuitable cover and prey (and water). The main exception would be a case where habitat alteration benefits one cat species to the detriment of another through interspecific competition. The clearing of coniferous forests for agriculture in the northern United States is one example: this has permitted the bobcat to expand some parts of its northern range, while the southern boundary of Canada lynx range has retreated (Rolley 1987). Although the physical structure of human-altered habitat is changed—sometimes radically—alternative sources of food and cover are generally available. Populations of rodents and birds, different from those found in forests, thrive in croplands and even cities. When forest is cleared for pastureland, wild ungulates may be replaced by domesticated livestock. When settlement encroaches on woodland and ungulates become scarce, pumas, leopards, tigers, and snow leopards have been known to take dogs. That rusty-spotted cats, a little-known species with a restricted distribution in India, have been found on several occasions to den and breed in the ceiling space of houses, while preying on domestic poultry (see species account), is testimony to felid adaptability.

However, the definition of "inadequate" and "unsuitable" will obviously vary among species, and it would be misleading to conclude that all cats are generalists that can live anywhere and eat anything. For example, some cats may be constrained in their ability to live in certain habitats through specialization for a certain size category of prey. If that size category of prey were to disappear (e.g., because of overhunting by humans) and were not replaced by similar species, cats might not be able to survive even if other, different sized prey, were available.

Breitenmoser and Breitenmoser-Würsten (1990) have discussed this subject with respect to the 20th century extirpation of the Eurasian lynx from southern Europe. The Eurasian lynx, the largest of the lynxes, is adapted to prey chiefly on smaller ungulates (unlike the three other lynxes, which favor rabbits). In southern Europe, small ungulates consisted of two species, the roe deer and the chamois, until they were almost completely extirpated by the late 19th century. Although livestock (sheep and cattle) were available, husbandry in the mountain uplands of this region tends to be migratory, whereas the lynx, like most cats, is territorial. While direct persecution may have been the primary cause of the extinction of lynx in the lowlands, an inadequate prey base in the highlands, despite good quality habitat and availability of small prey, appears to have been a major factor in the loss of the lynx.

Inadequate suitable prey could also explain the disappearance of other cat species from viable habitat, such as the lion and leopard from North Africa, where the wild ungulates have been severely reduced in number, and the livestock husbandry which has replaced them is nomadic. Of the big cats, only the cheetah, which follows migrating herds of Thomson's gazelle in the Serengeti (females and non-resident males only: Durant *et al.* 1988), has persisted in any number in the Sahara and Sahel regions. Similarly, the rarity of the Andean mountain cat may be attributable to the virtual extinction of the mountain chinchilla (see species account).

This review indicates that habitat loss and fragmentation are not the main threat facing cats, although they are closely and inextricably linked to it. Degradation of the vegetation base upon which herbivores depend may reduce the number of suitably-sized ungulate prey so that cats cannot sustain themselves. Although shifting cultivation has been characterized as good wildlife habitat, this is only true if carried out in a traditional, sustainable manner. Otherwise, severe habitat degradation can result (McNeely 1994).

Persecution, both direct and indirect, is the primary cause of declining cat populations. Indirect persecution consists chiefly of overhunting the prey species upon which cats depend. If the only suitable prey available in modified habitat is livestock, persecution then becomes direct. This problem is addressed in the next chapter, Management. The most direct form of persecution is commercial hunting, which is discussed in Chapter 4, Trade.

It is not that conservation of natural habitat is unimportant for cats: on the contrary, it is because of losses to persecution that the need for relatively undisturbed conservation areas becomes paramount. Rather, it is a matter of emphasis and prioritizing limited resources for cat conservation. Cats are wide-ranging and thinly distributed, and for most it will be impossible to protect all but a small proportion of their historic ranges. It is encouraging that cats are among the more adaptable species which are capable of coping rather well with the changes that the growing human population is making to the world environment. Human settlement, activity, and development are not necessarily inimical to cats. Future efforts need to be directed towards understanding to what degree cat species tolerate habitat loss, fragmentation, and modification; developing guidelines as to how land use can be modified to allow cats to persist; and finding ways to reduce persecution of cats (especially the big cats) in habitat used by humans. The following review of the world's system of protected areas and their significance for cats will show why the issue of conservation in human-occupied landscapes is so critical.

The Role of Protected Areas in Cat Conservation and the Need for Linkages

According to WCMC (1992), there are more than 8,800 protected areas in 169 countries covering some 7.7 million km^2, or 5.2% of the earth's land area (not including multiple-use or partially protected hunting areas, nor private reserves.) Most of these have been established relatively recently, i.e. since the early 1960s. Table 10 outlines the protected area network of this Action Plan's five geopolitical regions, based on data published by the World Conservation Monitoring Centre. Although the figures mask a good deal of variation between countries, broad regional trends are apparent. In Africa and southwest Asia, protected areas tend to be few but large, while in Eurasia, they are many but small. Tropical Asia and the Americas fall somewhere in between.

Given the prevailing rates of tropical deforestation, it is encouraging that the regions with the greatest proportion of protected land area are in the tropics. About 5% of the tropical forest biome is now protected in reserves (WCMC 1992). Heywood and Stuart (1992) have noted that this percentage is rising rapidly, and has its distribution heavily skewed towards the most diverse sites (as indicated by bird and mammal distributions). While legally protecting habitat has had only a minor impact on global deforestation rates, there have been important advances in mitigating the anticipated effects on biodiversity.

No cat species lack protected areas within their ranges, and the presence of all but two (Chinese mountain cat, Andean mountain cat) has been confirmed in at least one protected area. No cat species are presently confined only to protected areas.

Ehrlich's (1988) assertion that "the loss of genetically distinct populations within species is, at the moment, at least as important a problem as the loss of entire species" is highly relevant to the widely distributed cat family. Overall, regional populations or subspecies are more critically threatened than species, and the most important contribution that protected areas currently make to cat conservation is helping to prevent intraspecific genetic erosion by protecting important sub-populations.

The tiger is a good example of how quickly local extirpation can happen. Two distinct island populations (Bali and Java) and an isolated race found along watercourses in the west Asian deserts (Caspian tiger) have been lost within the past 20-40 years. A fourth subspecies, the South China tiger (which, based on morphological evidence, appears to be the most primitive tiger from which the other races evolved [Herrington 1986]), has been reduced to a handful of scattered individuals. The Amur tiger is seriously threatened by a very recent wave of commercial poaching, and the Sumatran race, confined mainly to the island's major reserves, is estimated to number only 400-600 (Tilson 1992a).

Using the snow leopard as another example, two subspecies have been named but are not generally recognized (Hemmer 1972). A. Kitchener (*in litt.* 1993) has suggested that the species is a prime candidate for significant intraspecific variation, given the isolating effects of both the permanent snowfields at high altitude and densely settled valleys within its range. With a patchy distribution, snow leopards are particularly vulnerable to local extirpation, which has been anecdotally reported across much of their range (Jackson 1992).

While tigers are increasingly rare outside protected areas, most snow leopards inhabit unprotected lands. The different situations of these two species, the rarest of the big cats, each with an estimated global population of around 6,000 (Jackson 1993a, Fox 1994), make useful case studies to illuminate both the benefits and limitations of the role currently played by protected areas in cat con-

Table 10
Protected Area by Geopolitical Region

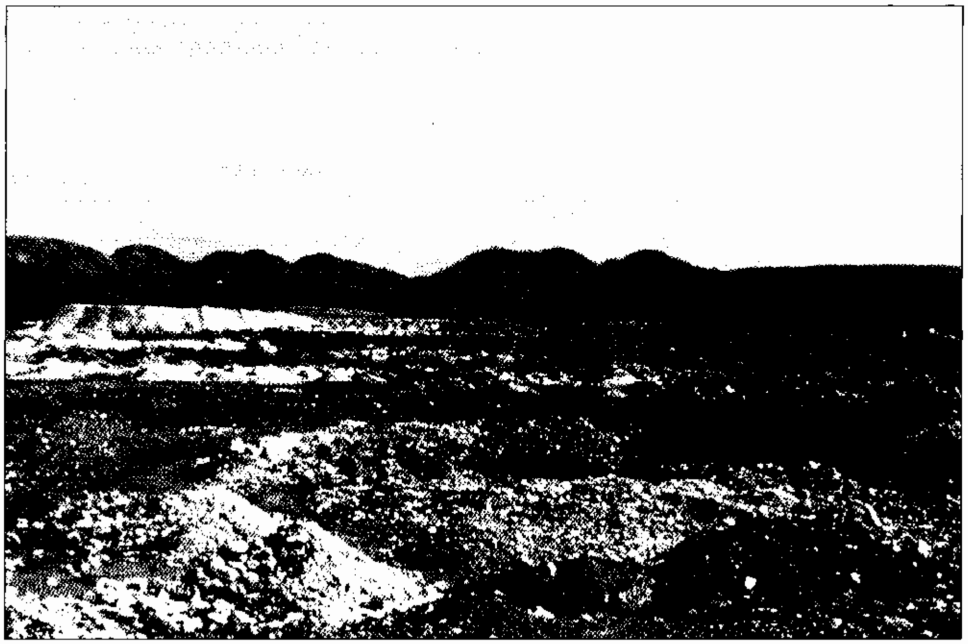
Region	Percentage of Land Area Protected		Number of Protected Areas		
	Regional	Average	Regional	Average National	Average Size (km²)
Sub-Saharan Africa	5.2%	5.2%	599	15.0	1,989
Range		0-17.4%			
Standard deviation		4.55			
North Africa and Southwest Asia	3.4%	1.9%	230	12.1	2,056
Range		0-10%			
Standard deviation		3.0			
Eurasia	2.7%	7.9%	3,454	123.4	306
Range		0.1-25%			
Standard deviation		6.3			
Tropical Asia	5.9%	6.3%	865	86.5	519
Range		0-19.5			
Standard deviation		5.7			
Americas	7.0%	7.0%	2,189	95.2	1,229
Range		0-31%			
Standard deviation		7.2			

Source: WCMC (1992)

servation. Since India's approach to tiger conservation has not only been pioneering, but has also relied mainly upon protected areas, discussion centers largely on that country. For the snow leopard, the role of protected areas in conserving minimum populations has been examined recently by Jackson and Ahlborn (1990), Fox (1994), Green (1994), and Villarubia and Jackson (1994).

Serious public concern about the decline of the tiger arose only in 1969 at the 10th session of the IUCN General Assembly in New Delhi, where a precipitous decline in numbers of the Bengal tiger was documented. Seven of the eight tiger subspecies were already listed in the IUCN Red List of Threatened Species, and as a result of the Assembly discussions, the Bengal tiger joined them. The Indian government subsequently placed the tiger under total legal protection from hunting and trade, and conducted a nationwide census. The resulting estimate was of the order of 1,800 tigers (Govt. of India 1972), compared with a possible 40,000 at the turn of the century (Gee 1964). Project Tiger was launched by the government in 1973, with the objective of employing the tiger as a flagship species to focus effort on habitat preservation and conservation of sympatric species. Both central and state government resources were concentrated on improving the viability of a set of "Tiger Reserves" selected according to ecological diversity (23 in 1995). Annual expenditures have been of the order of U.S. $4,000,000, and the states have sustained an annual loss of about $14,000,000 by giving up logging operations within reserve borders (Panwar 1987). The reserves were designed with central core areas afforded total protection, surrounded by buffer zones where some local exploitation, such as livestock grazing or tree felling, may be permitted. The government came to recognize that conservation-oriented community development in the areas surrounding the Tiger Reserves would be vital to Project Tiger's success (Panwar 1987, Anon. 1990f). However, in densely settled and poverty-stricken rural India, reconciling the needs of nature reserves with those of surrounding communities has proved an elusive goal (Thapar 1992, Govt. of India 1993, Jackson 1993b), and progress in implementation has been slow and patchy.

Overall, Project Tiger has been successful in its primary objective of conserving the tiger; the decline was not only arrested, but reversed. According to the results of the



Peter Jackson

Dolomite mines infringing on Sariska Tiger Reserve in India.

1993 nationwide census, the tiger population was officially estimated to be 3,750 (Nath 1994), more than double the 1972 figure. There have been numerous other gains, as well. The tiger effectively served as an umbrella species, and other species have benefitted from improved habitat protection and management in reserves with tiger populations. Perhaps most importantly, the tiger served as a charismatic flagship species around which the conservation movement in India rallied and grew. When Project Tiger was initiated, government forests (which make up most of India's forest cover; Govt. of India 1991) were managed almost exclusively for timber production; but thereafter the importance of wildlife conservation was recognized. In the Project's early years, there was a pervasive atmosphere of enthusiasm and hope among the conservation community, especially the government officials charged with the tiger's conservation (M.K. Ranjitsinh, pers. comm.).

However, the main threats posed to the gains made by Project Tiger indicate the first important obstacle to realizing the full potential contribution that protected areas can make to the conservation of cat populations: unless the resource needs of local people are somehow satisfied and integrated into reserve management, no officially protected area can really be protected effectively on the ground. The Indian government acknowledges that commercial poaching for tiger bone has become a serious problem in the 1990s (Govt. of India 1993). The difference between the 1993 census figure of 3,750 and the 1989 figure of 4,334 suggests that nearly 600 tigers have been lost, but the unreliability of the census figures make an accurate assessment impossible. Moreover, seven Tiger Reserves have become refuges for political militants, which has made management "exceedingly difficult" (Govt. of India 1993). Most of the reserves are subject to illegal grazing and tree felling, and all suffer from the antagonism of people living just outside reserve borders. Thapar (1992) has documented the destructive nature of a system of complicity and corruption between state-assigned officials and villagers in the area of the Ranthambhore Tiger Reserve, leading to severe habitat degradation and a breakdown of law and order.

The situation of the snow leopard is similar, but not as drastic, given the difference in human population densities between the central Asian highlands and southern Asian lowlands. Green (1994) reviewed the status of 47 protected areas in the mountains of central Asia where snow leopard presence has been confirmed. Of these, 65% are inhabited by people, and 86% provide grazing for livestock. Livestock predation is a major problem (Miller and Jackson 1994), and commercial poaching for pelts and bones has been reported (R. Jackson, pers. comm.). In general, there has not been much effort to integrate local requirements with conservation objectives, although there has been progress in Pakistan (Ahmad 1994) and Nepal (R. Jackson, pers. comm.). Similar programs are being planned in China (R. Jackson, pers. comm.) and India (Govt. of India 1988).

These problems are not unique to India, a densely populated country, nor to central Asia, where populations are of much lower density but clustered. Protected areas around the world face the same sort of threats emanating from outside their borders, and managers are increasingly focusing on developing locally appropriate solutions to resolve conflicts between parks and local people (McNeely and Miller 1984, MacKinnon *et al.* 1986, IUCN 1992b).

The privately-sponsored Ranthambore Foundation in India is relevant as a case study. It was established in 1987 to support development projects aimed at reducing villages' dependence on the Ranthambore Tiger Reserve, which is coming under increasing pressure as the land outside the reserve has suffered severe degradation. The Foundation's activities include distribution of indigenous seeds for tree planting, programs to improve livestock management, provision of primary health care and promotion of innovative and sustainable income generation projects. The Foundation also supports educational and cultural activities aimed at restoring traditional links to and respect for the Ranthambore environment (Fig. 3). International financial support is provided by an affiliated organization, Global Tiger Patrol, a British-based charity which organizes and supports similar programs elsewhere in tiger range.

The second major problem with protected areas for cats is that big cats, in particular, are wide-ranging and thinly distributed, and isolated reserves surrounded by a hostile environment need to be large enough to protect against the extinction pressures which threaten small populations. The concept of minimum viable population (MVP) size is discussed more fully in Chapter 3, Research. It should just be noted here that an MVP is a relatively small, isolated population, but one still large enough so that the chances are good that it will survive for at least 100 years. Extinction pressures which threaten its survival include unpredictable environmental and demographic events (e.g., a virulent epidemic, a massive forest fire, or disruption of breeding dynamics, such as through a chance imbalance of sex ratio), in addition to harmful genetic processes (accumulation of deleterious mutations, loss of genetic diversity) to which small populations are vulnerable. As a general rule, an isolated MVP should number in the hundreds of *breeding* individuals—which means potentially a thousand or more animals (Lande and Barrowclough 1987).

With reference to field conservation, small population biology is still largely a theoretical rather than an applied science (Caughley 1994). Although there are questions regarding the consequences to wild populations of loss of genetic diversity (see, for example, the cheetah Species Account), prudence dictates that the warnings of small population biologists be heeded.

The vast majority of the world's protected areas are too

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Ranthambhore Foundation medical service for villages around tiger reserve, Ranthambhore, India, part of a program to improve the lives of local people and relieve pressure on tiger habitat.

small to support MVPs, certainly of the bigger cats, and of many of smaller species as well. Approximately one-third of the world's protected areas are between 10-29 km^2 in size, and 85% are less than 1,000 km^2 (WCMC 1992).

To return to the Indian tiger: most of the 21 Tiger Reserves which are managed by Project Tiger are virtual islands of habitat in densely settled areas and, even including their partially protected and often highly disturbed buffer zones, they may not be large enough to conserve viable tiger populations. The areas of the 21 Tiger Reserves in India range from 521 km^2 to 3,568 km^2 and average 1,500 km^2, but more than half are less than 1,000 km^2 in size. According to the 1993 census, based on pugmarks, the average tiger population in each reserve was 65 (range 17-251), including sub-adults. Yet these censuses have been criticized as unreliable because of imprecise methodology (Karanth 1987, 1993b), and poaching has severely reduced the population in at least one reserve (V. Thapar, pers. comm.). It is thus likely that breeding populations within these reserves are considerably lower than the official estimates would indicate. Tigers are also found in approximately 100 other protected areas in India, but the average size of these reserves is less than half as large as the Tiger Reserves (Johnsingh *et al.* 1991; Wildlife Institute of India unpubl. data). Strictly protected areas make up only a small part of India's forest cover. According to census data, more than half of the country's total tiger population lives outside these areas, in forests managed for timber production (H. Panwar, pers. comm. 1988).

The snow leopard's status in Nepal resembles that of the tiger in India—no protected areas are large enough to support viable breeding populations (Fox 1994)—but, unlike the tiger, most of its good quality habitat lies outside the reserve network (Jackson and Ahlborn 1990, Fox 1994). Assuming snow leopard presence in all suitable habitat types, and using a range of densities according to the degree of habitat suitability, Jackson and Ahlborn (1990) estimated that 65% of Nepal's snow leopard population occurs outside protected areas. Out of all the country's national parks and reserves, only the proposed Annapurna Conservation Area—if fully implemented would come close to harboring a large population (projected at 156 adults based on habitat suitability). However, most villagers surveyed who live within one part of the Annapurna CA wished to see snow leopards completely eradicated because of livestock predation (Oli *et al.* 1994).

The tiger population in the Indian sub-continent is highly fragmented. Smith and McDougal (1991) estimated that most sub-populations have fewer than 10 breeding individuals, with very few as high as 50. Tiger populations in Thailand are also known to be widely separated. Snow leopard populations, on the other hand, tend to be naturally fragmented due to the patchy nature of high alpine habitat, dissected by deep river valleys which are heavily settled (Jackson and Ahlborn 1990, Fox 1994). For most tiger populations, there is no effective movement between

Tigers view devastated land around Ranthambhore Tiger Reserve which was still forest in the 1960s. Painting by Gajanand Singh, Ranthambhore School of Art.

populations. The degree of migration between snow leopard populations has scarcely been examined, but is probably impeded in many places by settlement. Even a very low rate of immigration can, theoretically, substantially improve the viability of even very small populations (Allendorf 1983, Lande and Barrowclough 1987, Beier 1993). Beier's (1993) population viability analysis for pumas in southern California and Florida lends weight to a growing advocacy within the conservation community of the use of "corridors" to connect protected areas and permit movement between sub-populations.

Beier (1993) developed a density-dependent model that simulated the dynamics of small populations of pumas under varying environmental and demographic conditions. He did not consider the effects of inbreeding or genetic drift—taking genetic considerations into account greatly increases MVP size (Seal *et al.* 1989). His model indicates that if a wildlife movement corridor is available to allow immigration of just a few individuals per decade, an area as small as 600-1,600 km^2 (depending on the demographics of the particular population) can support a puma population without significant extinction risk for 100 years. Isolated populations without immigration had a much higher risk of extinction, and did not persist "safely" in areas under 2,200 km^2. Beier's study (Beier and Barrett 1990-1992) of a small puma population (about 20 adults) in the Santa Ana Mountains of southern California documented the use of narrow corridors (one along a creek and another through a canyon) for both dispersal and movement between larger habitat blocks.

Corridors have attracted much attention in the wake of growing awareness of the vulnerability of small isolated populations, and because the concept of linkages between larger blocks of habitat makes sense intuitively (Simberloff *et al.* 1992). A corridor strategy, according to one of its chief proponents (Noss 1987, 1991), consists of maintaining or restoring natural landscape connectivity, not building connections between naturally isolated habitats. Because of their range requirements, large carnivores, particularly cats, are often used as examples of species which would benefit from corridors. Soulé (1991), pointing out that large animals, particularly predators, are thought to play a keystone role in maintaining habitat and species diversity, deems it "ecologically prudent" to attempt to ensure their presence, through corridors, in small habitat patches which could not otherwise support a permanent population. However, corridor strategies have been criticized because of the potential expense of purchasing narrow pieces of land in the vicinity of settlement or development (the same amount of money could buy more land in more remote areas). Critics further point to a lack of species-specific research documenting use vs. non-use of habitat corridors (Simberloff and Cox 1987, Simberloff *et al.* 1992).

The appropriate way to proceed would seem to be to recognize the potential significance of corridors for cat conservation, but to judge each case according to its merits. Beier (1993) and Maehr (1990) both document the importance of short, narrow natural landscape features in facilitating movement between fragmented puma sub-populations in southern California and southern Florida. These are clearly cases where maintenance or restoration of corridors would benefit locally scarce cat populations.

Research effort should increasingly be directed towards examining use of modified habitat by cats, and to identifying key habitats and potential corridors in settled areas where cat populations are either clustered or locally scarce. A GIS computer-based map overlay system is an asset to this process (Smith *et al.* 1987a).

In many cases, habitat corridors used by cats will be on privately owned land. For example, Maehr (1990) has emphasized that many pumas in Florida occur on private land, and that larger blocks of protected land are of marginal quality and support fewer animals. Governments should explore options beyond outright acquisition of privately owned wildlife habitat for protected areas. The best options provide economic incentives to land-owners to manage their land in a way compatible with species conservation. In developed areas, these would include both case-specific legal agreements as well as a broader system of tax write-offs (e.g., Logan *et al.* 1993). In developing areas, this could either take the form of preferentially focusing development activities on lands supporting key wildlife habitats or, as has been pioneered in southern Africa (Martin 1986), helping land owners to develop the knowledge and infrastructure to make maintenance of wild lands a type of land-use which is economically competitive with far more prevalent (and destructive) agriculture or livestock grazing.

There is a third reason why it is important for cat conservation to look beyond strictly protected areas: there are a number of constraints which limit the amount of habitat that governments can set aside as strictly protected. At the present time, protected areas comprise only a minor portion of cat species' ranges. If cat populations are lost over the next decade, they will most likely be lost on unprotected lands.

An analysis of the representation of cats in the world's protected areas has been carried out using data collected by the Protected Areas Data Unit (PADU) of the World Conservation Monitoring Centre. The figures presented in Table 11 are preliminary and necessarily inaccurate: data on confirmed occurrence of cats in protected areas is neither sufficiently comprehensive nor centralized, so that it was necessary to assume that protected areas falling within a species range actually contain the species (see Appendix 4 for details on methodology).

Rabinowitz's (1993) survey of tiger occurrence in pro-

Table 11
Protected Area for Cat Species (in order of vulnerability)

Species	% of Range Protected	Amount of Area Protected (km²)	Number of Protected Areas
Category 1			
Iberian lynx, *L. pardinus*	25-27%	10,000-50,000	50-150
Category 2			
Bornean bay cat, *C. badia*	2-3%	10,000-50,000	10-50
Chinese mountain cat, *F. bieti*	12-14%	10,000-50,000	10-50
Black-footed cat, *F. nigripes*	9-12%	100,000-250,000	10-50
Kodkod, *O. guigna*	25-27%	10,000-50,000	10-50
Andean mountain cat, *O. jacobitus*	6-9%	10,000-50,000	10-50
Flat-headed cat, *P. planiceps*	6-9%	100,000-250,000	50-150
Fishing cat, *P. viverrinus*	3-6%	100,000-250,000	290-350
African golden cat, *P. aurata*	6-9%	100,000-250,000	50-150
Tiger (A), *P. tigris*	12-14%	100,000-250,000	290-350
Snow leopard (A), *U. uncia*	6-9%	100,000-250,000	50-150
Category 3			
Cheetah (A), *A. jubatus*	6-9%	250,000-500,000	150-260
Asiatic golden cat, *C. temmincki*	9-12%	250,000-500,000	600-750
Oncilla, *L. tigrinus*	12-14%	250,000-500,000	150-260
Rusty-spotted cat, *P. rubiginosus*	3-6%	10,000-50,000	50-150
Clouded leopard (A), *N. nebulosa*	9-12%	250,000-500,000	600-750
Lion (A), *P. leo*	9-12%	550,000-700,000	290-350
Jaguar (A), *P. onca*	3-6%	250,000-500,000	150-260
Marbled cat, *P. marmorata*	6-9%	150,000-250,000	290-350
Category 4			
Sand cat, *F. margarita*	3-6%	100,000-250,000	10-50
Margay, *L. wiedi*	6-9%	550,000-700,000	290-350
Serval, *L. serval*	6-9%	550,000-700,000	290-350
Canada lynx, *L. canadensis*	12-14%	550,000-700,000	400-500
Geoffroy's cat, *O. geoffroyi*	2-3%	10,000-50,000	50-150
Manul, *O. manul*	3-6%	100,000-250,000	150-260
Category 5a			
Ocelot, *L. pardalis*	3-6%	550,000-700,000	400-500
Eurasian lynx, *L. lynx*	2-3%	250,000-365,000	400-500
Bobcat, *L. rufus*	3-6%	250,000-365,000	600-750
Pampas cat, *O. colocolo*	3-6%	100,000-250,000	290-350
Puma (A), *P. concolor*	6-9%	1-1.7 million	1000-1,500
Leopard (A), *P. pardus*	6-9%	1-1.7 million	1000-1,500
Category 5b			
Caracal, *C. caracal*	3-6%	1-1.7 million	600-750
Jungle cat, *F. chaus*	3-6%	250,000-500,000	400-500
Leopard cat, *P. bengalensis*	3-6%	250,000-500,000	1000-1,500
Category 5c			
Wildcat, *F. silvestris*	3-6%	1-1.7 million	1000-1,500
Jaguarundi, *H. yaguarondi*	3-6%	550,000-700,000	400-500

See the Introduction to the Species Accounts for explanation of the vulnerability ranking system (pp. 2-6).

tected areas in Thailand shows the risks of this approach: only 58% (n=22) of surveyed protected areas contained tigers, and the six largest sites contained 56% of the total estimated number of tigers in Thailand. Nonetheless, the financial incentive to poach tigers is high. It is this species that is most likely of the cats to be eliminated from protected areas, and it is for this species that the assumption of occurrence is the weakest.

Table 11 shows that, even for a species which has disappeared from much of its former range and now exists in highly fragmented sub-populations, the Iberian lynx, protected areas comprise only about one-quarter of its range. Most species have less than 9% of their range protected. Most of the cats with a greater proportion protected are vulnerable species ranked in Categories 1-3. Species with smaller ranges are more likely to have a greater proportion of their ranges protected than species with larger ranges, although the actual geographic area protected is smaller. The more unprotected range a cat loses, the more important protected areas become.

Protected areas are necessary for cat conservation and, given prevailing rates of habitat loss and fragmentation, their importance is likely to increase with time. However, cat conservation must have a two-pronged, interactive strategy. Protected area coverage for cats should be improved by: (1) establishing new protected areas to conserve important habitat or populations; (2) strengthening the protective infrastructure of threatened areas; (3) generating local community support for maintaining the protected area; and (4) taking measures to ensure that protected populations are of viable size. Furthermore, in order to better conserve both inter- and intraspecific diversity, as well as to promote connectivity between populations in protected areas, efforts must also be directed toward conserving cats in places used more intensively by people. This is especially problematic for big cats, as discussed in the next chapter.

Summary and Conclusions

1. Most cats are associated with forest habitat. Tropical moist and dry forests are particularly important. More vulnerable (Categories 1-3) species are associated with tropical rain forest than any other habitat type. Tropical Asia has undergone the highest rate of deforestation in the 1980s, and its moist and dry forests harbor more vulnerable species (Categories 1-3) than any other regional habitat type. Habitat conservation for cats is a priority here.

2. Four habitat types are of greatest importance for vulnerable cats: tropical rain forest, major wetlands, tropical montane complexes, and high alpine tundra. The first three types are declining in global area; the latter three habitats share the features of being small in overall area, and locally patchy or insular.

3. Global trends in habitat loss should not provoke undue pessimism as far as cat conservation is concerned. Cats appear to be relatively flexible in their habitat requirements, and can persist in many types of modified habitat. Research effort needs to be directed at defining the common denominators which allow such persistence (e.g., Projects 2 and 23 in the Action Plan, Part III).

4. No cat species appears to be imminently threatened with extinction due to habitat loss, but significant threatened sub-populations may need immediate protection through reserve creation. Status surveys should be conducted so that such populations can be identified; a number of priority projects in Part III are aimed at this. It is imperative that the establishment of new reserves closely involve local residents so that the effectiveness of the protected areas is not jeopardized.

5. The protected area network plays an important role in conserving individual cat populations. However, if isolated, most reserves are too small to support minimum viable populations. Corridors which permit movement between otherwise isolated populations could substantially reduce their vulnerability. Research effort should be directed at identifying where corridors potentially exist and documenting their use (e.g., Projects 3-4 and 50).

6. Protected areas cover only a minority of cat species ranges; most cats occur outside of protected areas, in human modified habitat. Conservation of cats is thus inextricably linked to development in both rich and poor countries. Cat specialists should become more involved in the development process. Their role is to study conflicts between people and cats, and to identify ways to reduce those conflicts so that both people and predators can coexist. This is the subject of the following chapter.

Part II
Major Issues in Cat Conservation

Chapter 2
Management of Big Cats Near People

Introduction

Conflict between livestock owners and predators has existed since food animals were first domesticated around 9,000 years ago. Domesticated animals have reduced escape abilities compared to wild herbivores, and are exceptionally vulnerable to predation, which is a problem wherever wild cats and livestock share range. The previous chapter showed that most cats occur outside protected areas, and that most habitat outside protected areas has been modified by humans. Livestock husbandry is a major form of land use, and if livestock replaces wild prey it becomes the chief suitable sustenance for cats. This is especially true for big cats—many smaller cats subsist on rodents, which can increase under some forms of agriculture and livestock husbandry. Peoples' persecution of the larger cats for predation on livestock, or for the danger they can pose to human life, is the final step in the process of their disappearance outside protected areas, which starts with habitat loss and fragmentation. To prevent further erosion of cat range and numbers, ways must be found for people and cats to live together.

Laws against indiscriminate killing of big cats are one of the primary reasons that populations still exist near people. Enforcement of protective measures for cats will always be a fundamental component of managing these populations, and conservation of cats living near people could be greatly improved with sufficient resources and training for national and local government wildlife authorities. This is particularly true for developing countries with impoverished people and limited resources to spend on wildlife conservation. It is imperative that countries which have well-managed and successful wildlife protection programs increase their financial and technical assistance to those which do not. This can only be of benefit to cat conservation.

However, laws protecting cats and their prey from indiscriminate killing are often not sufficient to curb the fundamental pressures leading to their decline outside protected areas. Where cats are perceived as a nuisance or an economic liability, people take the law into their own hands. This chapter thus focuses on two strategies to encourage people to tolerate the presence of cats.

First, the problem of cat predation, on both livestock and people, is reviewed, and a number of measures which can be taken to mitigate predation are put forward. Management to reduce the impact of predation on livestock is one of the most important elements of a cat conservation strategy. The extent of the predation problem is reviewed, and a number of mitigating measures evaluated. Such measures are aimed at halting direct persecution of cats, on the assumption that, if predation problems are few, local people and land owners will leave cats alone. However, if livestock is safely protected, and there are no alternate suitable wild prey available, cats will still not be able to persist in such areas.

It will not be possible for most governments to set aside much more of their wild lands from development. The second strategy, therefore, aims to provide incentives for landowners to maintain wild lands with cat populations, rather than convert land to forms of use which are inhospitable to cats. Since the conversion of wild lands is taking place for reasons which are primarily economic, so too must be the incentives to conserve them instead. This is an emerging field in wildlife conservation, and pilot projects have been established based upon local people earning money from the sustainable use of species ranging from trees to iguanas to butterflies to antelope. However, economic incentives to specifically conserve cats are few, since cats more often have costs than value. Two of the main options (tourism and hunting) are reviewed, and further application discussed. A third, commercial trade in cat products, is reviewed in Chapter 4.

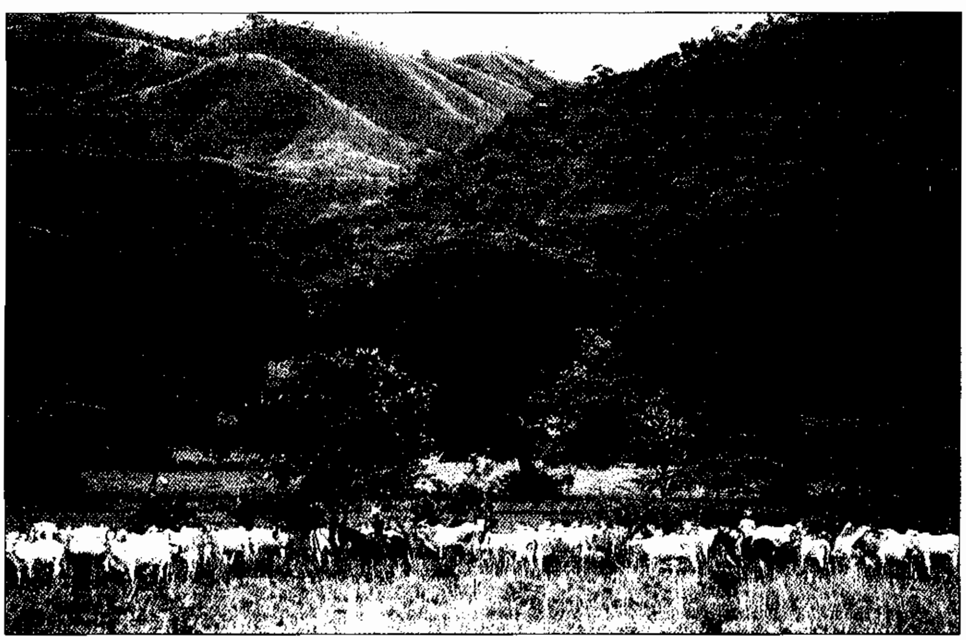
Cat Predation on Livestock

Persecution by humans in response to livestock predation, both actual and potential, has been a major factor resulting in the disappearance of big cats from large areas of their former range in historical times, including the puma from eastern North America, the tiger from most of China, and the lion from north Africa and southwest Asia. In many cases, the big cats were declared vermin and bounties paid by the government for skins. The recent, rapid global increase in human numbers, and the concomitant spread of settlement, agriculture and other activities, have widened the arena where conflict between cats and people occurs. In India, for example, which supports 15% of the world's cattle and over half the world's tigers, the human population has risen by nearly 50% since the initiation of Project Tiger in 1973 (Jackson 1993a).

Most cats—all the big cats, and many of the small—take livestock, from horses and cattle to poultry. Especially with regard to the big cats, livestock predators are found to have been crippled by injuries, old age, or disease, which could have been a handicap to their taking wild prey. Jim Corbett (1944), the famous hunter of tigers and leopards turned man-eaters in India, was one of the first to point out the link. Rabinowitz (1986) in Belize and Hoogesteijn *et al.* (1993) in Venezuela reported that more than half the jaguars killed for livestock predation that they had examined had old head or body wounds. Most of the problem jaguars (n=13) examined by Rabinowitz (1986) had head wounds, but none of the skulls of 17 non-problem jaguars had injuries. However, healthy cats also take livestock (Hopkins 1989).

Some studies have shown that stock-raiding cats are more likely to be males than females (Suminski 1982, Rabinowitz 1986), and more likely to be sub-adult than adult (Rabinowitz 1986). Others, such as Bown's (1985) survey of North American management authorities on puma predation, have found that adults of both sexes are more often implicated than younger animals. Perhaps Sitton's (1977) observation that it is impossible to predict which cats will turn to stock raiding is still valid (Lindzey 1987). Both Suminski (1982) and Rabinowitz (1986) observed that some big cats ignored available livestock prey, while others became "addicted." Of nine leopards monitored by Mizutani (1993) living on a Kenya ranch (where wild ungulate prey was available), only one habitually took livestock.

On the other hand, in the special circumstances of ranching on the outskirts of protected areas, the most likely stock raiders are dispersing sub-adults. For example, Anderson (1981) reported that male lions were destroyed outside the borders of South Africa's Hluhluwe/Umfolozi Game Reserve complex twice as often as females. Most of the males were less than three years old (20 out of 25). Sub-adult males, having left the reserve, seldom returned, whereas there were over 50 incidents of females with cubs leaving and returning immediately. Males were found much further from the park boundary (mean of 23 km) than females (mean of 0.6 km). Stander (1990) classified lions from Namibia's Etosha National Park which took livestock on border ranches as either occasional raiders (lions with known histories and no previous record of stock raiding) or problem animals (habitual raiders). The



Peter Jackson

Cattle on ranches in the Venezuelan llanos are attacked by jaguars and pumas, which are persecuted by ranchers as a result.

sex and age structure of occasional raiders was similar to that of the entire Etosha population, with slightly more sub-adults of both sexes. Most problem animals, on the other hand, were sub-adult and adult males. Stander (1990: 41) described these lions as "very wild and difficult to immobilize or destroy. They were...apparently aware of the dangers involved." In India, sub-adult lions (both male and female) were significantly more likely than adults to raid livestock on the outskirts of the Gir Lion Sanctuary. Saberwal *et al.* (1994) concluded that the Gir lion population is at saturation density, and the sub-adults were seeking both food and territory.

Cat species differ in their livestock prey and mode of capture. For example, on a ranch in Brazil, pumas killed mainly calves, with some sheep, while jaguar kills were 33% calves, 57% cows, and 10% oxen and bulls (Crawshaw and Quigley in prep.). Mizutani (1993) looked at predation by lions, leopards, and cheetahs on a mixed livestock ranch in the Kenyan highlands. One leopard climbed into the newborn calf enclosure to take calves, on average one per month. Leopards also killed stray animals left outside the fenced enclosures at night. Lions roared outside the fenced enclosures holding cows and steers, causing the animals to panic and sometimes break through the fence. Cheetahs took sheep rather than cattle, attacking during the day when they were spread out grazing. All three cats together took about 1% of the ranch's total stock on an annual basis.

On a large scale, livestock losses to cats are generally low, of the order of <1-3% of total stock per year (Jackson *et al.* 1994). Ginsberg and MacDonald (1990) came to a similar conclusion in their review of livestock predation by canids. Estimates of annual stock losses to pumas in the United States range from a high of 7% of sheep in a problem area of southwestern Utah (Bowns 1985) to a low of 0.3% of sheep in Nevada (Suminski 1982). Evans (1983) concluded that verified puma predations affect fewer than 1% of ranches in New Mexico on an annual basis. Similarly, predation by African wildcat and caracal accounted for the loss of only 1.1% (1,508 animals) of small livestock held by farmers in the Nuwe-Roggeveld district of South Africa's Cape province in 1984-1985 (Vorster 1987). In Namibia, interviews with ranchers by the Veterinary Services Department of the Ministry of Agriculture (unpubl. data, Cheetah Conservation Fund) show that leopards and cheetahs were each responsible for an average annual loss of approximately 320 cattle and 375 sheep and goats between 1986 and 1991. On a national level, the yearly losses to these two cats combined is equivalent to only 0.03% of total cattle holdings, and 0.01% of total small stock.

However, the impact of cat predation is highly variable on the scale of individual livestock operations. For example, Hoogesteijn *et al.* (1993) compared cattle deaths on Venezuelan ranches. On the first ranch, deaths due to big cat predation were considerably fewer than other causes of calf mortality, and accounted for only 6% of all losses or deaths. The ranch was well managed but, following the owner's declaration of a ban on hunting jaguar, the proportion of deaths attributable to cats rose to 15%

Peter Jackson

Goats, nicknamed "Billy the desert-maker," in a Nepalese wildlife reserve prevent regeneration of the forest, which is the vital habitat of tigers and their prey.

(about 40 calves per year). However, the owner maintained the hunting ban. On another ranch, smaller than the first and situated in a more agriculturally developed area, cat predation accounted for 31% of calf losses or deaths (between 1-6 calves per year). Big cats were resident on the first ranch, but not on the second.

While the economic impact of livestock predation can be significant even for larger industrialized ranches, on a smaller scale, particularly in developing countries, the loss of just a few domestic animals can be a major setback. Oli (1994) surveyed villages in Nepal's Manang District, situated within the Annapurna Conservation Area, the largest reserve in Nepal for snow leopards. He recorded 72 animals lost to snow leopards in 1989-1990, representing 2.6% of the livestock held by 102 households, with a total value of U.S. $3,866. This represents an average household loss of 0.7 animals, valued at about $38—a substantial amount for the local people in a country where the average rural annual income is just $122 (Anon. 1990a), among the lowest in the world. Some households were affected more than others. One family lost two adult horses in one attack, with an economic value equivalent to six times the average rural annual income, while another lost 11 goats, representing 20% of their livestock. These losses were serious enough to upset the household economies for several years. The high value of these losses led to considerable antipathy toward snow leopards on the part of local villagers: 97% wished to see snow leopards eradicated.

Similarly, the area of Namibia formerly known as Bushmanland is largely undeveloped, with only subsistance livestock husbandry. In eastern Bushmanland, there are only 29 villages, with average stock holdings of 16 cattle and two horses. In 1992-1993, lions killed livestock on nine occasions, taking eight cattle (1.7% of the total number kept in eastern Bushmanland) and four horses (9.3% of the total). The affected villages suffered an economic loss of U.S. $56 (Stander 1993). However, the Ju/'hoan residents have little cash income, and still depend mainly on hunting (20%) and gathering (80%). The loss chiefly represents a setback to efforts to establish a sustainable cattle industry for food supplementation (Anon. 1992d). The losses contributed to the desire of 84% of villagers surveyed that lions be eliminated (Stander 1993).

Local antipathy toward cats as predators is magnified by the phenomenon of surplus killing. When a cat breaks into a fenced enclosure and encounters large numbers of prey animals, it will sometimes kill more than it needs to eat. Fenced animals cannot escape the predator, and their panicked movements repeatedly stimulate the cat's killing instincts. Surplus killing is a rather frequent phenomenon; it is common for pumas in North America to kill more than one animal per attack if small stock (sheep, goats, poultry) are involved, but with cattle, most kills are single animals (Sitton *et al.* 1978, Bowns 1985, Jalkotzy *et al.* 1992). In South Africa, Stuart (1986) found that 73% of 104 livestock kills by leopards and 22% of 79 caracal kills (mostly sheep) in Cape province were of two or more stock animals. One leopard killed 51 sheep and lambs, while caracals have been recorded to kill 21 and 22 sheep in single incidents (Skinner 1979, Stuart 1986). Other spectacular examples include single pumas killing 59 sheep (mostly lambs) in Nevada (Suminski 1982), and 420 chickens in Canada (Jalkotzy *et al.* 1992). In Tibet, the killing of 107 sheep by one snow leopard in a single night was reported (Jackson *et al.* 1994), and a snow leopard in Ladakh was known to have killed 40 sheep and goats (Fox and Chundawat 1988). Guggisberg (1961) reports six lions killing 51 ostriches kept in an enclosure. In all these incidents, only a small proportion of the animals killed were actually eaten.

To sum up, livestock predation is a significant problem on a local, rather than national or regional, level. It causes the greatest amount of economic hardship in poorer, developing regions with few livestock per household. Predation incidents can arouse considerable hostility toward wild cats.

Management to Minimize the Problem of Livestock Losses to Big Cats

The traditional response to livestock predation has been to attempt to eliminate all predators in the area. Nowak (1976) has documented that government-sponsored predator control efforts in western North America were responsible for the death of nearly 67,000 pumas between 1907 and 1978. However, it is rather surprising, given historical success in eradicating populations, that more modern attempts have generally failed (Lindzey 1987). For example, the complete elimination of pumas from problem regions in New Mexico has been attempted three times—twice to protect domestic sheep and once to protect wild sheep. None of these removals resulted in a reduction of predation (Evans 1983), and pumas are still there today. One reason may be that the vacuum was rapidly filled by immigrants from neighboring areas, such as occurred when lions were culled from a section of South Africa's Kruger National Park (Smuts 1978). Another may be that big cats eventually adapt to persecution, and become more secretive and more difficult to catch.

Nowadays, management measures to minimize livestock predation take three forms: attempts to eliminate the specific animals causing the damage; improved anti-predator and general livestock management; and compensation for livestock lost to predators.

Problem Animal Control

In most cat range states, it is permissible for predators which take livestock to be killed or removed. Regulations vary as to whether the livestock owner himself may take action, or must call upon a government animal control officer to do the killing, and to what degree predation must be verified before elimination of the problem animal is sanctioned. The following examples give an indication of the range of variation.

In India, predation on cattle is common news in all parts of the country (Sawarkar 1986), which supports 15% of the world's people, 15% of the world's cattle, and 54% of the world's tigers. The government has prohibited the killing of big cats: the only exception is elimination of a confirmed, deliberate man-eater. In extreme (and rare) cases of persistent livestock predation, the offending animal may be captured and either translocated to a reserve or given to a zoo (S. Deb Roy, pers.comm.).

In Namibia, cheetahs are significant problem animals, and land owners are permitted to kill cheetahs "to protect the life of livestock, poultry, or domestic animal...while the life of such livestock is actually being threatened." The owner is then required to report to the nearest wildlife authority within 10 days to obtain a permit for possession of the skin (Nature Conservation Ordinance, 1975). The government does not verify specific predation incidents, although predation is monitored in a general way through twice-annual visits of veterinary control officers to every commercial ranch in Namibia. Lions and leopards are not currently listed as protected game, and land owners may legally kill them in response to livestock predation with no official reporting requirement.

Both approaches have their problems. The problem in Namibia is that the management strategy does not prevent indiscriminate killing, resulting in the loss of large numbers of cheetahs which are not problem animals. Most cheetahs end up being shot in a trap, rather than killed in the act of predation (L. Marker-Kraus *in litt.* 1993). Over 5,600 cheetahs were killed in the period 1980-1991, according to official statistics (Govt. of Namibia 1992). Some ranchers have gone to a lot of trouble: over the same period, one rancher killed 175 cheetahs on his property, an average of 16 animals a year (Kraus and Marker-Kraus 1992). The number of cheetahs killed annually in Namibia shows a declining trend, down from 850 in 1982 to 301 in 1990, probably indicating a declining population.

In India, it can take a long time for an official to arrive at the scene of the predation, and in practice they often never arrive. The degree to which people take the law into their own hands and kill big cats is unknown. Because of the danger of increasing illegal persecution of cats, Johnsingh *et al.* (1991) and Saberwal *et al.* (1994) urge that the authorities attempt to eliminate problem animals, as quickly as possible, irrespective of the species involved.

In practice, problem animal control is most efficient, in terms of minimizing livestock predation as well as conserving cats, when the actual problem animal is targetted. It is best to target problem animals specifically because they may lead others to kill livestock. For example, with

Peter Jackson

Puma captured for attacking livestock on a Venezuelan ranch.

Box 1
Predators and Farmers

South Africa's Endangered Wildlife Trust has produced an information booklet for livestock keepers entitled *Predators and Farmers* (Bowland *et al.* 1993). The booklet is useful and the information is well presented: it deserves imitation elsewhere. The first part consists of brief accounts, with distribution maps and photos, of large and small carnivores found in the region, with notes on their beneficial activities. The booklet explains the importance of determining whether the prey animal was killed by a predator or died of other causes and was just fed upon, and explains how to determine this by skinning the carcass and looking for mortal wounds and other evidence.

The book contains photos illustrating the various predator "signatures": for example, in comparison to other predators, cat species are much more likely to feed upon a prey animal's inner and/or outer thighs in a "clean and tidy" manner. Paw prints and hairs of each carnivore species are drawn clearly to aid diagnosis. The book emphasizes that predator control efforts can be costly, and that before undertaking any action a farmer should compare the costs of losses to predators with the costs of predator control. He may find he can live with certain levels of predation, but more often some form of predator control is necessary.

Predators and Farmers is available from the Endangered Wildlife Trust, Private Bag x 11, Parkview 2122, South Africa.

lions, Stander (1990) found that occasional raiders sometimes accompanied problem males on forays into cattle ranches. Females which take to livestock predation may teach their cubs to kill stock.

While it is best to have an expert tracker and identify the animal, this is not always feasible. Many cats will return to a kill if it is left alone: this is probably the best way to identify the actual killer, although the kill may be investigated by another, innocent predator. Well-trained dogs may also be able to pick up and follow the scent trail of a cat which does not return to a kill (Stuart 1982).

One innovation for targeting problem animals is the toxic collar, a broad collar put around the necks of domestic animals, with a capsule of powerful poison attached where the collar runs under the animal's throat. Cats generally kill larger livestock with a throat bite, and are poisoned when they bite through the collar and its capsule. Such collars are used in some developed countries, including France, the U.S., and South Africa. This allows the livestock owner to target actual livestock killers, without having to involve a government problem animal officer—such people, if they exist at all, are usually too few or too busy to respond to all reported predation incidents efficiently. Collars could be made available to ranchers at low, subsidized rates.

A similar technique is the placing of traps, either lethal or steel-jaw traps, near livestock areas, but these traps are often indiscriminate and may catch innocent animals. F. Mizutani (*in litt.* 1993) is experimenting with aversion training by injecting the carcasses of livestock killed by leopards with the nauseating substance lithium chloride. One leopard which killed a sheep came back to eat the treated carcass and did not return to livestock killing.

Rather than being eliminated, problem animals can be translocated. But translocations have met with mixed success (Hamilton 1976, Seidensticker *et al.* 1976, Mills 1991, Anderson 1992). Habitual problem animals often return to stock-killing (Rabinowitz 1986, Stander 1990). Stander (1990) was able to return occasional raiders to their home ranges within Etosha National Park, with only one of 12 translocated lions resuming stock raiding. However, in practice, the original home range of a wandering predator will seldom be known. Translocation is discussed in greater detail in Chapter 6.

Improving General Anti-predator Livestock Management

Livestock owners may exaggerate their losses to big cats by including losses due to other causes, including poor management techniques. Even on the conservation-minded ranch in Venezuela mentioned earlier, where jaguar hunting was banned despite an increase in calf losses, ranch managers estimated annual losses to big cats at 200 animals, but careful investigation of carcasses by Hoogesteijn *et al.* (1993) showed that only 40 calves a year were killed by cats. Hoogesteijn *et al.* (1993) listed other causes of calf loss as: injuries inflicted during round-up or transportation, snake bite, drowning, disease, and slaughter for human consumption. Mizutani (1993) adds theft to the list. L. Marker-Kraus (*in litt.* 1993) cites leg injuries caused by falling into burrows (common in arid regions), abortions in cattle and small stock, poisonous plants, and birthing problems with first-time heifers. Other predators may turn out to have a more significant impact than cats: in a problem zone in southwestern Utah, for example, it was estimated that coyotes were responsible for 92% of sheep losses, and pumas for 7% (Bowns 1985). In California, domestic dogs are responsible for more sheep deaths than pumas (Trulio 1989).

By improving basic livestock management, owners can reduce losses to causes other than big cats, and increase their profitability. Such measures include vaccination of livestock against disease, and improved husbandry measures to increase pregnancy and juvenile survival rates. For example, Hoogesteijn *et al.* (1993) noted that only 40-50% of beef cattle pregnancies in the Venezuelan llanos are successful, and only 30-40% of calves reach breeding age. L. Marker Kraus (*in litt.* 1993) reports a 55% calving rate in Namibia; in other words, 45% of heifers that could reproduce do not do so.

With specific regard to improving anti-predator management, the following general principles can be recommended (Stuart 1982, Evans 1983, Bowns 1985, Ginsberg and MacDonald 1990, Oli 1991, Kraus and Marker-Kraus 1992, Quigley and Crawshaw 1992, Bowland *et al.* 1983, Hoogesteijn *et al.* 1993, Mizutani 1993, Jackson *et al.* 1994; see Box):

- Proper disposal of livestock carcasses so that predators do not acquire a taste for livestock;
- Changing from cow-calf to steer operations where losses to big cats are heavy;
- Guards or guard dogs for daytime grazing (or even, as the Cheetah Conservation Fund of Namibia has suggested, donkeys or baboons);
- Controlling birth seasons rather than allowing births to take place randomly;
- Keeping cows and calves under closer supervision when calves are young, and away from areas of thick vegetation or rough terrain where cats may lurk;
- Keeping, rather than selling or trading, experienced herd lead animals, so that they can teach appropriately cautious behavior to younger animals;
- Keeping a few cows or steers with horns in the calving herd;
- Rounding up livestock at night into soundly fenced enclosures and posting armed guards with lights;
- Improving the security of fenced enclosures through better fencing, including, where economic, electric;
- Permitting wild prey species to co-exist with domestic livestock;
- Fencing off ranch areas which adjoin prime cat habitat, or avoiding grazing in such area.

Jim Thorsell

Mountain lion killed in Utah.

Compensation for Livestock Losses

Paying compensation for livestock losses is a way of encouraging land owners or local people to tolerate predator presence. In some places, compensation is paid by the national or local government, while in others, compensation is paid by conservation groups. Compensation can be an effective tool when it is not abused. Several compensation progams are reviewed below.

When lynx were reintroduced in France, Switzerland, and Austria, sheep losses provoked great hostility from farmers towards lynx conservation. Although sheep losses were low (400 lost in Switzerland over 15 years) compared to annual livestock losses to lynx and other predators elsewhere in Europe, farmers raised a great outcry which threatened the success of lynx reintroduction. Compensation was paid voluntarily in Switzerland by the Swiss League for Protection of Nature, and in France by WWF-France. In 1988, the national and local Swiss governments took responsibility for paying compensation. At the present time, Switzerland pays out about U.S. $18,000 annually as compensation for lynx kills, a small sum compared with the nearly $35,000,000 invested annually as a subsidy for sheep husbandry. Compensation is thus not a major economic outlay, and has helped to smooth public acceptance of the lynx (Breitenmoser and Breitenmoser-Würsten 1990).

In North America, two American states (Wyoming and Colorado) and one Canadian province (Alberta) pay compensation for livestock losses to pumas. In Alberta, the Livestock Predator Compensation Program covers only food-producing stock (i.e. cases of predation on dogs or horses are not covered), and market value of a loss must exceed CA $100 (U.S. $72) per calendar year. Reported incidents of predation are investigated by provincial wildlife officials, and claims for compensation are reviewed by one of two regional committees composed of private producers and government representatives from animal health, production, and wildlife management interests. Losses are judged as "confirmed kill," "probable kill," or "missing animal," and include livestock fatality, injury from which recovery is deemed improbable, and the disappearance of animals in conjunction with confirmed kills or injuries. Since June 1990, the program has paid 100% compensation for confirmed kills, 50% compensation for probable kills, and no compensation for missing animals (previously, 30% compensation was paid). From 1974-1987, 61 claims for puma predation were approved for compensation, an average of 4.4 per year. For every approved puma claim, there were five wolf, 13 bear, and 42 coyote claims approved between 1974-1983 (Pall *et al.* 1988). Annually, total compensation for puma kills averages only CA $1,617 (U.S. $1,171: Jalkotzy *et al.* 1992). In Colorado, annual compensation paid for puma kills is considerably higher: U.S. $45,000 in 1990-1991 (Hansen 1992). Hansen (1992: 62) interviewed J. Talbott, Assistant Chief Warden for the Wyoming Fish and Game Department, about the effectiveness of compensation in terms of puma conservation. Talbott believed that Wyoming's program "increases tolerance of the cougars and helps ranchers view them as a bona fide wildlife resource that people like to see out there."

A major issue in North America is that puma predation often takes place on minimally supervised public lands leased to private individuals for livestock grazing. Expenses of livestock compensation programs extend considerably beyond the actual compensation paid out, and include costs of monitoring, verification, negotiation of compensation, and administration. In its puma management plan, the government of Alberta province (Jalkotzy *et al.* 1992) gives predator control measures lowest priority on public grazing leases, although compensation is still paid. The California-based Mountain Lion Foundation suggests that occasional losses of livestock to pumas on grazing lands leased by the public be tolerated by the owners as "part of the price of doing business" (Hansen 1992: 111).

In India, state governments are responsible for dealing with livestock predation according to guidelines issued by the central government. When an incident is reported, a wildlife official carries out an investigation in the presence of the complainant and some other villagers. No compensation is payable if the incident occurred inside a protected area, or the carcass has been disturbed in any way. The amount paid out varies from state to state and is related to the age and sex of the animal and its intrinsic value—e.g., compensation is higher for milch cows and buffaloes, and draught animals. It is difficult to evaluate the success of these programs. In the Gir Forest area, Joslin (1984) declared that the compensation scheme for livestock losses was of limited practical benefit to herdsmen. A decade later, the situation had not improved: 81% of Gir area villagers interviewed by Saberwal *et al.* (1994) said they did not bother to file claims. The problems they cited included low level of compensation in comparison to the purchase price of replacement animals; excessive travel to report losses; the likelihood that an official would not be available to register a report of livestock predation within the mandatory reporting period (24 hours); subjective assessments by officials of the worth of predated livestock; and difficulties associated with receiving payment for settlements.

Somewhat similar to official compensation is private insurance for livestock losses. However, it is doubtful whether any individual owner sustains high enough losses from cat predation to warrant paying for such insurance. On the other hand, in at least one area of Canada's province of British Columbia, sheep losses to coyote predation were so high that insurance coverage was withdrawn (I. Ross *in litt.* 1993).

Paying livestock compensation can be a relatively low-cost way to encourage livestock owners to tolerate the presence of cats, for, even with the most advanced stock husbandry, some losses to predators are likely to occur. Oli (1991) reviewed various management options available to reduce livestock predation by snow leopards in Nepal's Annapurna Conservation Area, and concluded that a livestock compensation fund, locally administered, had the best potential to reduce the conflict between local people and snow leopards. He suggested that a Snow Leopard Conservation Committee be formed of prominent village representatives, an NGO representative (Annapurna Conservation Area Project), and the local wildlife authority. It would be up to the Committee to develop the details of the scheme (procedures for claim, levels of reimbursement, etc.) and inform the villagers about it. Oli suggested that compensation be paid only for verified snow leopard livestock kills in cases where appropriate measures were taken to avoid predators, and not be paid for the loss of male yaks or oxen left unattended throughout the year, the loss of an animal not corralled at night, or the loss of an old, injured, diseased, or otherwise dying animal. The scheme should be simple enough to permit illiterate villagers to make claims properly, but effective enough to detect and discourage abuse.

Oli discussed both the pros and cons of his compensation idea, which are a useful summary for compensation schemes in general. The merits of the compensation program include: (1) it is the management method most acceptable to the community (as snow leopards cannot legally be eradicated); (2) it involves a direct financial incentive, so that livestock owners are more likely to cooperate with laws protecting the snow leopard; (3) the scheme involves an endowment fund, with the interest used to pay compensation, so that it is sustainable; (4) the management committee will consist mainly of local representatives, so conservationists will not solely be held responsible for any perceived shortcomings in the scheme; (5) as the management committee will act as a liaison between the conservation authority and local people, it will aid implementation of other conservation measures.

Drawbacks of compensation include: (1) livestock losses from any cause may have to be compensated because it is impossible to go to the site and determine the actual cause of death on all occasions; (2) false claims could be difficult to detect, and compensation of such would set a bad precedent; (3) it is possible that local people will accept compensation but continue to kill snow leopards secretly, and it would be difficult to determine that this was happening; (4) management committee members might use their position to political advantage, leading to a general loss of faith in the compensation scheme; (5) if the committee fails to function efficiently and impartially, it will reflect badly on the conservation authority.

Programs Which Make Wild Lands an Economically Competitive Form of Land Use

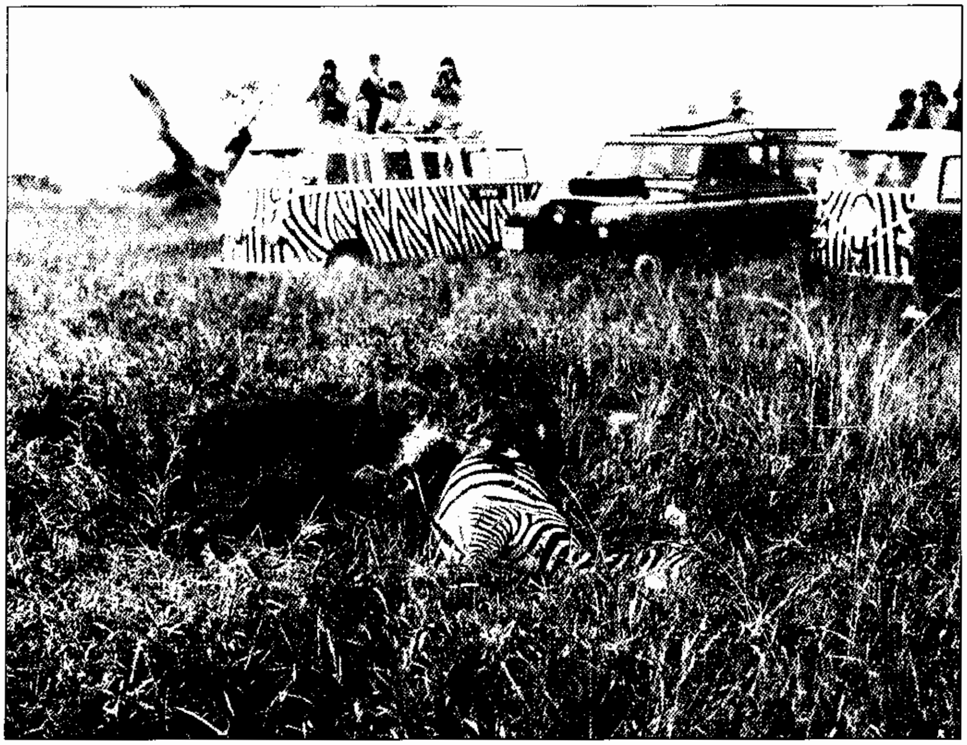
Conservation of cats outside protected areas will be a battle of attrition, especially for the big cats, where the wild prey base has been eliminated. If wild ungulates are killed off to make room for cattle, there is little hope that cat populations will persist in these areas. If protective livestock management works, there will be nothing for the cats to eat.

For this reason, the recent and increasing interest on the part of the conservation community in promoting ways in which wild lands, with their full complement of species, can be an economically competitive form of land use, is of great significance. Perhaps the best example of how successful such policies can be are the state-owned and private hunting concessions in North America and Europe. Considerable revenue is generated from the sale of hunting licenses and other associated infrastructure for the budgets of wildlife authorities. Tourism is also significant, but not to such a high degree as in protected areas.

In terms of cat conservation, however, the most promising examples are projects in developing countries which work with local people so that use of wild lands is not only sustainable, but also profitable. Such programs concentrate on the economic and resource values of wild plants and animals, particularly the large ungulates. A key con-

Peter Jackson

Tourist meets a tiger in India. Controlled tourism can promote wildlife conservation.



Tourists viewing lions on a zebra kill in east Africa, where wildlife tourism is a major source of foreign exchange, but requires stricter control.

cept is that landowners must benefit economically from wildlife if they are to refrain from converting wild habitat to other forms of land use. This concept is operative not only in development-oriented programs like Zimbabwe's CAMPFIRE (Communal Areas Management Plan for Indigenous Resources), but also in a growing commercial interest in converting African cattle farms to game farms.

While these new developments in conservation are exciting, their contribution to cat conservation has yet to be proven. Cats themselves have limited economic value, and most game farms and organized wildlife producer communities rely on the value of large wild ungulates as meat and trophy animals, although there are numerous other values to be derived from wild animals and plants. While it is these types of schemes which have the greatest potential to contribute to cat conservation outside protected areas (since populations of cat prey species are conserved), it is possible that local managers will see cat predation much the way livestock owners do: as an unacceptable cost of doing business. In southern Africa, for example, most game farms, especially those managed for meat production, but also those with valuable trophy antelope, do not tolerate big cats.

Specific economic incentives to conserve cats are few. One is the value of their fur. This value is limited by international trade restrictions and declining public demand as a result of conservation campaigns. The only examples of managed commercial cat fur harvest, the bobcat and Canadian lynx, are discussed in Chapter 4. The only other economic values of cats are tourism and trophy hunting: these are discussed below, with specific reference to their contribution toward conservation of cheetahs on private land in Namibia as a case study.

Tourism and Trophy Hunting

There are few places in the world, apart from savannah and some other non-forested parts of sub-Saharan Africa, where cats are easily visible, although the knowledge that they are present, and the chance of catching a fleeting glimpse and finding tracks, adds a special attraction to wildlife areas. Where tourists can expect to see big cats, these species have a significant role, and generate revenue. Over a decade ago, Thresher (1982) calculated the tourist value of a male lion in Kenya's Amboseli National Park to be U.S. $128,750. He surveyed tourists visiting the park, found that most desired to see full-grown male lions with "proper" manes, and that they spent about 2.5% of their game-watching time observing such lions. He derived his dollar figure by allocating responsibility for 2.5% of the park's annual income to male lions, divided by the number of lions in the park, and multiplied by a lifespan of 10 years. This is, of course, a highly theoretical exercise. The park would not necessarily lose 2.5% of its income if lions were to decline or disappear although it might lose more.

Martin and de Meulenaer (1988) calculated that a leopard was worth U.S. $50,000 annually to the privately-owned Londolozi Game Reserve in South Africa, assuming the highly-visible leopard there to be responsible for one-fifth of the net profit of U.S. $250,000 a year. However, they declare that most countries in Africa lose money from wildlife tourism when the full costs are taken into account, thus suggesting that leopards in general have negative value.

In India, the secretive tiger has become visible in a few reserves as a result of effective protection and the habituation of some individuals to the approach of people in vehicles or on elephants. These reserves have generated tourist revenue but, apart from some employment in hotels or as drivers, local communities have not benefitted, and the wildlife authorities have not received any significant contribution towards reserve management costs.

Namibia is home to an estimated 2,500 cheetahs, with the vast majority of the population found on private commercial cattle ranches (Morsbach 1987). Such private lands, where other large predators (lion and hyena) have disappeared, are thought to be of critical importance to conserving viable populations of cheetah, whose numbers may be limited by these competing predators in reserves. Wildlife tourism (including both camera and rifle safaris) is a major sector of the Namibian economy (Berry 1991c), and a recently established NGO, the Cheetah Conservation Fund, is attempting to promote the country as "the cheetah capital of the world." A major tenet of national wildlife policy is that landowners are encouraged to maintain wildlife on their property and to reap economic benefits from it. Cheetahs in Namibia are thus an ideal case study of the contribution economic value can make to cat conservation. If such a strategy is to work anywhere in the world, Namibia stands a good chance.

However, tourism on private land faces stiff competition from larger, more spectacular protected areas, and cats on private game farms or on relatively undeveloped communal lands almost assuredly attract fewer tourists than in protected areas. If tourists coming to Namibia want to see cheetahs and can make only one stop, they are far more likely to go to Etosha National Park rather than a game farm. The decision to visit a game farm is likely to be more related to the quality of amenities offered rather than the presence of cheetahs. Many guest farms in Namibia keep semi-tame cheetahs around their premises. Such animals are a strong attraction after the hands-off policies of national parks and reserves, but game farms can keep tame cheetahs without keeping wild ones. As previously mentioned, game farm managers are often opposed to keeping cheetahs and other predators because they prey on valuable antelope, usually purchased by the manager.

Tourism is an industry subject to a host of vagaries, most importantly the state of the economy of developed countries from where most tourists originate. While tourism is currently on the rise in Namibia, future growth is unpredictable, and in the end has little to do with cheetahs. It can be concluded from this discussion that tourism does make a contribution to conservation of cheetahs on private lands, but it is a small one. Moreover, the more countries with cheetahs on private lands which duplicate Namibia's private game farm strategy, the more likely the value of a cheetah will fall due to competition for a limited resource (tourists).

A number of African countries permit sport hunting of lion, leopard, and cheetah (Martin and de Meulenaer 1988). For cheetah and leopard, which are on CITES Appendix I, hunters are able to take their trophies back home under a quota system approved by CITES. Trophy hunters spend considerably more per capita in host countries than do tourists: Makombe (1994) notes that the price tag for a 21-day lion hunting safari in Tanzania is around U.S. $35,000, much more than a tourist would spend visiting the country. Moreover, hunting revenues can make a substantial contribution to governmental income. For example, in 1990, government revenues from hunting licenses in Tanzania amounted to some U.S. $4,500,000, more than twice the revenue earned from the national parks system ($1,900,000: Makombe 1994). Revenue from sport hunting can be a key part of sustainable use of wildlands schemes. In a review of sport hunting as a sustainable use of wildlife, Edwards and Allen (1992) report that communities participating in the (CAMPFIRE) program earned $4,000,000 from sport hunting in 1990-1991, representing about $400 per household. In some communities, this represented a doubling of annual household income.

Namibia has a well-developed sport hunting industry. From 1983-1991, safari hunters took an average of 21 cheetahs per year (Govt. of Namibia 1992). Most of these were shot on private land, although mainly on game farms or hunting concessions rather than commercial cattle farms or communal land. While the total amount of money spent by a trophy hunter during his stay can be considerable, the trophy price for a cheetah is currently rather low, with a high of U.S. $1,500 and a low of $600. In contrast, zoos sell live cheetahs for prices between U.S. $6,000-10,000. Moreover, in some cases, trophy animals were purchased from farmers who had trapped them, rather than tracked and hunted on a game farm (L. Marker Kraus *in litt.* 1993).

In order for trophy hunting to play anything but a minor role in cheetah conservation, cheetah trophy hunting would have to expand a good deal, especially into cattle ranches where most cheetahs occur and cause the most problems. The Cheetah Conservation Fund has been holding discussions with the Professional Hunters Association of Namibia regarding increasing promotion of the cheetah as a trophy animal along with raising the trophy fee, with a portion of the fee to be channeled back into cheetah conservation (L. Marker-Kraus, pers. comm. 1994).

While both tourism and trophy hunting help conserve cheetahs on private land in Namibia, their contribution at present is of limited utility, and does not begin to compensate for the hundreds of cheetahs killed annually on cattle ranches as problem animals. If the contribution of economic use options for the conservation of cats outside protected areas is to be increased, specific cooperative effort on the part of conservationists and the tourism and trophy hunting industries is required.

Martin and de Meulenaer (1988) stress that sport hunting should not be considered a replacement for problem animal control in Africa because livestock predation tends to occur at times when hunters are not active, and they do not particularly like to hunt in heavily-settled rural areas. On the other hand, Swank and Teer (1988) proposed limited and controlled sport hunting of problem jaguars in Belize, Brazil, Mexico, and Venezuela, arguing that the fees could provide a major portion of the finances needed by government agencies to implement management measures and, in part, to compensate local people for cooperating in the plan. In India, Saberwal *et al.* (1994) considered the problem of local antipathy to problem Asiatic lions in the Gir Forest to be so serious that they also suggested that the sport hunting option be considered, despite the fact that the subspecies is very rare, and that no sport hunting of big cats is permitted in India. None of the countries named has implemented these proposals.

Summary and Conclusions

1. Most of the world's cats occur outside of protected areas, where the most direct threat is human persecution. For the larger cats especially, active management and protection measures are needed to ensure their conservation in areas used by people.

2. Predation of livestock is the primary cause of people's intolerance of cats. Although on a large scale predation rates are fairly insignificant, averaging 0.1-3%, their importance is magnified at the level of individual owners, especially in developing countries. To poor people, the loss of just a few animals represents a major financial setback, and provides a strong incentive for extermination of cat populations.

3. Measures to minimize livestock predation include problem animal control, improving general anti-predator stock management, and paying compensation for livestock taken by cats. There is relatively little material available about how to implement these measures effectively (e.g., see Action Plan Projects 5, 32, 52, 74, 93, and 102 in Part III).

4. Big cats are also persecuted because they are a danger to people, and in some cases tigers, lions, and leopards have become man-eaters, specializing in human prey. In general, however, most attacks on people are the result of accidental, rather than deliberate, confrontations. A number of suggestions are made for how people can avoid or escape big cat attacks (see Box 1, Big Cat Attacks on People).

5. Even if livestock predation can be minimized, the chances of cats surviving on unprotected lands are slim if there are no wild prey there to support them. For this reason, the growing movement to develop economic incentives to make maintenance of wild lands a viable alternative to agriculture and stock husbandry is a welcome development. In most cases, conservation of wild ungulate populations for meat or trophy hunting is one of the best incentives, and this is of great potential significance for cat conservation. However, managers of wild game are likely to be as hostile toward cats as managers of domestic livestock, viewing predation as an unnecessary cost. Cat specialists should become involved in such cases to test ways to encourage the conservation of cats under these circumstances (see Action Plan Project 22).

6. The economic values represented by cats themselves are few, consisting of tourism and hunting. Commercial hunting in North America for the fur trade is reviewed in Chapter 4. Tourism and trophy hunting can be an incentive for the conservation of cats on unprotected lands, but their impact is limited at present. If tourism and trophy hunting are to play a major role in cat conservation, it will require that cat specialists cooperate with the industries to work toward this goal (see Action Plan Projects 31 and 33).

7. It is difficult to develop recommendations on conservation of cats outside protected areas, in part because there is no professional disclipine which embraces the subject. Conservation of viable big cat populations near people is highly complex but also extremely important. The Cat Specialist Group has recognized this (CSG 1984, McNeely 1991), and a number of group members work on resolving human-predator conflicts, but none full-time. There needs to be more recognition of the significance of this subject, and development of a professional capacity to address the problem (see Action Plan Project 6).

Box 2
Big Cat Attacks on People

The Nature and Extent of the Problem

Tigers, lions, and leopards have long been notorious for fatal attacks on people. They are frequently termed "man-eaters," but the term is, in general, unjustified. The existence of dedicated man-eaters is a fact, but many fatal attacks are the result of a cat's defensive reaction to the surprise appearance of a human.

"Tiger" and "man-eater" have become almost synonymous, although the number of attacks is remarkably low when the opportunity offered by human presence is taken into account. One of the worst affected areas, the Sundarbans mangrove forests in eastern India, has an unofficial death toll of about 100 people per year—although this is perhaps exaggerated, the official average being 36. While high, these figures have to be set against the fact that 35,000 people move through the Sundarbans each year (Chakrabarty 1992).

McDougal (1987) points out that there are certain regions where conflict between people and tigers has been historically minimal, and cases of man-eating are comparatively rare. He mentions Burma, Malaysia, Sumatra, Thailand, and Vietnam. On the other hand, southern and northeastern China, Singapore, and India have had serious and persistent man-eater problems.

At present, two areas are noted for tiger attacks: the Sundarbans, and the district of Kheri in northern India, bordering southwestern Nepal. The two areas illustrate different aspects of the problem.

The Sundarbans is an example of people moving into tiger range. There is no permanent habitation in the interior of the Sundarbans. People enter the forest to fish, cut wood, and to gather honey and other forest products. The only drinking water available is saline; high tides submerge large areas twice daily; and protruding spiked air-breathing roots make walking difficult. Nevertheless, although the area appears to hold ample wild prey, Sundarbans tigers have for centuries been known for unusually aggressive attacks on human visitors and deliberate man-eating. A French traveller in India in the 17th century, François Bernier, recounted how tigers took fisherman from their boats (Bernier 1670). In 1791, a British hunter was taken by a tiger in broad daylight while lunching with friends (The Gentleman's Magazine 1793). Such behavior still occurs, and has been documented by Chakrabarty (1992). Hendrichs (1975) and Chakrabarty (1992) speculate that the aggressive nature of the Sundarbans tigers could be due to the effects of excessive salt imbibed while drinking. But this is discounted by others, and the Sundarbans tigers' historical predilection for humans could perhaps be more simply attributed to local "culture," with cubs learning to identify humans as prey from their mothers.

Given existing patterns of human use of the Sundarbans forests and the peculiar habitat conditions that exist, man-eating is unlikely to be eliminated, although it has declined to some extent in recent years as a result of better regulation of human activities and special measures to deter tigers. However, as already noted, tigers attack a relatively small percentage of the large number of people who knowingly venture into dangerous areas of the Sundarbans, and there are no records of tigers going out of the forests in search of human prey.

The second case involves tigers moving into settled and cultivated areas. Dudhwa National Park, at the foot of the Himalayas in Lakhimpur-Kheri district of Uttar Pradesh, has become increasingly isolated from previously contiguous areas of wild habitat in the last 40 years. Surrounding grasslands have been converted to sugarcane cultivation right to the edge of the park. The park is home to a healthy tiger population, but dispersal to other areas has been disrupted by intensive human settlement and activity. Sugarcane fields attract wild ungulates from the park, which are followed by tigers. Since the typical cultivation regime of sugarcane involves long periods of tranquility and relatively little human activity in the fields, tigers tend to become resident and breed there, preying on any wild ungulates or cattle in the area. In such a situation, there is a high possibility of confrontations between tigers and people entering the fields. Between 1978-1988, 197 people were killed and 33 "man-eating" tigers shot in the Dudhwa area (Khushwah 1990).

Lions in both Africa and India have attacked people and become man-eaters. Despite an epidemic of attacks in the early years of the 20th century, the Asian lions of the Gir Forest in Saurashtra, western India, have become renowned for their passivity. However, a new wave of attacks began in 1988, and up to March 1991

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lions had mauled 120 people, of whom 20 died (Ravi Chellam and Johnsingh 1993b). The attacks have been linked to the decline of the local cattle population during a prolonged drought. The surviving cattle have been more carefully protected. This has led to more aggressive hunting by the lions, for which livestock has long formed an important part of diet. They have broken into the compounds of houses where livestock is kept at night by tearing off roof tiles. The lions have thus come into conflict with people, resulting in injuries and death. In a review of the problem, Saberwal *et al.* (1990) noted that the 1901-1904 epidemic of lion attacks (during which at least 66 people were killed) also followed a drought.

Conflict between lions and people in Africa has been less well documented, probably because news media are not so developed as in India. Guggisberg (1961) has documented a number of attacks on people throughout the continent, and the infamous man-eaters of Tsavo in Kenya (Patterson 1907) still vie for public attention with the man-eating tigers of Kumaon in India (Corbett 1944). During the 1980s, fatal attacks by lions in southern Tanzania were attributed to heavy poaching of wild ungulates, so that lions deprived of natural prey turned to livestock and entered villages, where they killed people (Anon. 1987b).

E. Marshall Thomas (1990, 1994), whose family has a long history of association with Bushman groups living in the Kalahari Desert, offers an interesting insight into why lions may be peaceable or hostile toward humans. In the 1960s, when she lived there, and for thousands of years previously, the lions and the Bushman people had an "arrangement." They hunted the same prey and made use of the same waterholes, both a precious resource in the Kalahari. She points out that the average group size of Ju/hoan people and the average pride size of lions were of equivalent weight, so that a meat meal sufficient for a group of people would also satisfy a group of lions. The lions and the people occasionally helped themselves to each other's kills, and compromised regarding the waterholes: the people occupied them during the day, and the lions during the night. No one could remember an incident of a lion attacking a person, with the exception of a paraplegic girl who was killed, and Thomas knew of no lion killed by a Bushman,

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Peter Jackson

Nepalese villager killed in an accidental confrontation with a tiger, which was later captured and placed in Kathmandu Zoo.

although everyone had heard of lions attacking Bantu people, who kept cattle and hunted lions. Thomas writes, "No one can explain the truce, because no one understands it. The truce was simply taken for granted, as most situations involving animals are simply taken for granted. Animals are assumed to be static in nature. So even today, with both the human and the animal populations stressed and damaged, few people realize the difference between how things are now and how things once were."

For comparison, she describes the unpredictable and sometimes aggressive behavior of lions in Etosha National Park, where Hei//kum Bushman people had lived until the 1960s. Her explanation is that the lions there lost their cultural heritage of how to live amicably with humans, once the people who lived there were removed, and the people who came afterwards (the tourists) were confined to automobiles. The first recorded incident of "tourist"-eating recently took place in Etosha (Nowell *et al.* 1994).

The leopard is a naturally secretive big cat, which is able to live in surprisingly close proximity to humans, and leopards which turn to man-eating have proved extremely difficult to hunt down (Corbett 1948, Turnbull-Kemp 1967). Attacks tend to be nocturnal. In India, leopards have claimed victims in rooms full of sleeping people without causing any disturbance (Corbett 1944). Other people have fallen victim to lurking man-eating leopards when leaving their houses to relieve themselves at night. Leopard attacks on people have always been common in hill areas of India and Nepal, where rugged terrain provides cover. They have also occurred around dwellings in the vicinity of the Gir Forest (Ravi Chellam *in litt.* 1992).

There is little documentation of jaguar attacks on people, but A. Rabinowitz (*in litt.*) reports hearing many stories in Belize, Brazil, and Guatemala that lead him to believe that, under the right circumstances, attacks could happen. Forest dwelling Indians in Latin America say that jaguars take children (A. Michelangeli, pers. comm.).

Snow leopards have no record of killing people. Women and unarmed villagers, including teenagers, may chase snow leopards away from the goats they have killed in Himalayan villages without fear of attacks, while cornered snow leopards are surprisingly subdued towards humans throwing stones at them (Mallon 1987, R. Jackson, pers. comm.).

Wild cheetahs have also never been reported to attack people, although recently a cheetah which got loose in a zoo in Mississippi attacked a child, who escaped serious injury by "playing dead" (P. Jackson, pers. comm.).In North America, puma attacks on people, while unusual, have increased in recent years. Beier (1991) documented 53 unprovoked attacks in the U.S. and Canada between 1980 and 1990, of which nine were fatal. They included the killing of a five-year-old boy in 1989 and an 18-year-old jogger in 1991. Thirty of the 53 attacks occurred in British Columbia, with 20 on Vancouver Island. Hornocker (1992) speculates that long-term intensive hunting of pumas on the island has selected the most aggressive as survivors, although retaliation is usually thought to lead to cats becoming more cautious. The attacks appear to have increased as suburban settlements in the west encroach on puma habitat (Foreman 1992, Seidensticker and Lumpkin 1992).

Measures to Minimize Risks to People

While there are no guaranteed ways to avoid attacks by big cats on humans, the following suggestions may be helpful:

- Where big cats are liable to threaten people, circumspect behavior is called for. People in groups are generally safe, but children especially excite the interest of big cats and are more vulnerable (65% of 58 known victims of puma attacks were less than 16 years old: Beier 1993). Care should be taken where cover may conceal a resting cat. A warning shout or other noise to announce an approach is likely to cause it to move away. For example, many people living in wild environments are purposefully noisy when walking from place to place in order to scare off potentially dangerous animals. Talking quietly to or yelling at a threatening cat may scare it off. Thomas (1990) describes the way Ju/hoan Bushmen spoke to lions on a kill which they intended to rob, speaking "firmly but respectfully." Beier (1993:409) describes how a 50-year-old female hiker, attacked and knocked down by a puma, set up her backpack as a shield, faced the puma, and (in her words) "began talking to her the way you would if you were trying to soothe a dog or cat." She kept this up for 30 minutes until she heard other hikers nearby and yelled for help; their noisy approach (with one hiker blowing a whistle) scared the cat away.

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- When threatened by a big cat, it is dangerous to turn and run—in at least two cases, running appeared to stimulate a puma to select the victim out of a larger group. However, running up a tree might help, although in one puma attack, the two cats climbed after the girl, who kicked them and hit them with a stick to make them leave (Beier 1993).

- Seidensticker and Lumpkin (1992) stress the importance of maintaining eye contact with a threatening cat, as well as taking care not to bend or squat. In the Sundarbans, the use of face masks, worn on the back of the head, has proved a deterrent to tigers, who usually attack from behind. Large eye spots on the back of a cap may also be effective.

- Throwing objects at an attacking cat may help and, once attacked, 20 of 29 puma victims successfully fought off the cats with bare hands, a stick, a knife, a jacket, or a rock. In several cases, even children unassisted by adults were able to repel pumas by fighting back. In several other cases, children carried off by pumas obeyed their parents' instructions to "play dead" and were limp. The pumas, although carrying the children, did not attempt to kill them, and people were able to scare them off (Beier 1993).

- Attacks should be investigated immediately to establish whether they were accidental (perhaps arising from the cat being surprised), or a case of deliberate hunting. If an attack is clearly determined to be deliberate, the wisest course of action is to eliminate the problem animal as soon as possible. If the attack appears to be the result of a surprise confrontation, no action need be taken, unless the body has been eaten.

- Big cat attacks are perhaps most likely to occur in settled areas bordering protected populations of cats. A healthy population will include a dispersing class of both sub-adult animals seeking to establish a territory, and older former residents which have lost theirs. Both of these types of cats are prime candidates for becoming problem animals: the sub-adults have immature hunting skills, and the hunting efficiency of older animals is declining. If risks to people (or livestock) are unacceptably high in such situations, there may be no solution but a program of elimination of these "surplus" cats, which is generally what occurs, in an illegal, informal and indiscriminate fashion. In Nepal, for example, tigers and leopards which stray out of the Royal Chitwan National Park are often poisoned by livestock owners (Seidensticker *et al.* 1991, C. McDougal pers. comm.).

Peter Jackson

Woodsman in the Indian Sundarbans wearing a mask on the back of his head to deter man-eating tigers.

Part II
Major Issues in Cat Conservation

Chapter 3
Research

Introduction

Many priority projects in this Action Plan (Part III) fall under the aegis of research, although the reason for this may not be immediately obvious in a document concerned foremost with species conservation. To some, a call for "more studies" is seen as an obstacle to real conservation which, for cats (as discussed in Chapters 1 and 2), primarily involves maintaining a network of protected areas and improving conditions in the human-modified areas which lie in between. However, knowledge of basic natural history, including diet and habitat requirements, is scanty for most species, let alone subspecies. This will impede attempts to determine suitability of habitat corridors, and to prevent extirpation of cats from areas used by people. In the words of Caughley (1994), it is important that conservationists have confidence that their background knowledge of species' natural history is "adequate to avoid silly mistakes." Reliable gauges of animal abundance are important for planning conservation actions, and for assessing their actual impact. Long-term studies are necessary to provide meaningful insight into species biology. Finally, while the science of conservation biology—incorporating computer models which simulate population dynamics; molecular research; identification of uniquely adapted sub-populations; and evaluation of the effects of disease upon populations—continues to advance through the 1990s, the lack of data for most cat species means they will be left out unless field research efforts are intensified.

Table 1 summarizes the last few decades of research on cats, including field, captive, and laboratory studies. In general, research effort has been low (low or very low = 20 species, 56% of the 36 species in the family Felidae). Research effort has been exceptionally high and thorough for the northern group of species, the lynxes. Intraspecific biological and situational variation has been poorly represented for most cats (24 species; 67%). Most importantly, research effort has not been strategically focused. Effort has been low or very low for those species of priority conservation concern (vulnerability rankings 1-3; n=12 species, 63%). The priority species for which research effort has been high or very high are all big cats (cheetah, tiger, lion, snow leopard), which have both economic value in terms of tourism and trophy hunting, and cost, when they come into conflict with human interests, primarily livestock farming. In fact, all species for which research effort has been high or very high are "revenue earners" with legal value (nine species) and/or "revenue consumers" with problem animal status (seven species). Most species of conservation concern (14 species, 73% of Category 1-3 species) have no legal economic value.

Research effort has thus not been altogether strategic regarding conservation of the Felidae, being strongly correlated with legal economic value rather than species vulnerability. This is not necessarily a conscious choice by researchers. The big cats have been relatively well studied primarily because of their position at the top of ecological food chains, observability, and charisma. However, it is also these qualities which give them legal value (through tourist and trophy hunter interest) and cost (through predation of large livestock or man-eating). In addition, at first glance, the small spotted cats exploited for their fur would appear to be exceptions, as they have been commercially hunted in large numbers while there has been virtually no research effort. However, for the Latin American cats, the major period of exploitation took place 10-20 years ago (see Chapter 4, Trade), and was largely illegal. National government authorities, which often fund research, did not benefit. In the case of the leopard cat, which is legally harvested, the Chinese government has recently recognized the need for sustainable management, and has substantially reduced harvest and export quotas while a major research project is organized (Johnson and Fuller 1992, Johnson *et al.* 1993).

The conservation benefits of linking the ecological value of cats to an economic value have been emphasized in Chapter 2. Many, if not all, of the species which are of conservation concern have the potential to help meet the costs of their conservation through development of revenue-earning options, tourism being currently the most

Table 1
Research Effort for Cat Species

Species	Rarity Ranking	Research Effort[1]	Legal Value[2]	Distribution[3]	Representation of Variability[4]
Cheetah, *A. jubatus*	3(A)	High	T, H, P	S, N	Poor
Caracal, *C. caracal*	5b	Int.	P	S, N	Poor
Bornean bay cat, *C. badia*	2	V. low	0	T	Poor
Asiatic golden cat, *C. temmincki*	3	V. low	0	T, E	Poor
Chinese mountain cat, *F. bieti*	2	V. low	0	E	Poor
Jungle cat, *F. chaus*	5b	Low	0	T, E, N	Poor
Sand cat, *F. margarita*	4	Low	0	S, N	Poor
Black-footed cat, *F. nigripes*	2	V. low	0	S	Poor
Wildcat, *F. silvestris*	5c	Int.	P	S, N, E	Int.
Jaguarundi, *H. yaguarondi*	5c	V. low	P	A	Poor
Ocelot, *L. pardalis*	5a	Low	0	A	Good
Oncilla, *L. tigrinus*	3	V. low	0	A	Poor
Margay, *L. wiedi*	4	V. low	0	A	Poor
Serval, *L. serval*	4	Low	0	S, N	Poor
Canada lynx, *L. canadensis*	4	High	F	A	Good
Eurasian lynx, *L. lynx*	5b	High	F, P	E	Int.
Iberian lynx, *L. pardinus*	1	Int.	0	E	Good
Bobcat, *L. rufus*	5a	V. high	F, H	A	Good
Pampas cat, *O. colocolo*	5a	V. low	0	A	Poor
Geoffroy's cat, *O. geoffroyi*	4	Low	0	A	Poor
Kodkod, *O. guigna*	2	V. low	0	A	Poor
Andean mountain cat, *O. jacobitus*	2	V. low	0	A	Poor
Manul, *O. manul*	4	V. low	F	E	Poor
Leopard cat, *P. bengalensis*	5b	Low	F	T, E	Poor
Flat-headed cat, *P. planiceps*	2	V. low	0	T	Poor
Rusty-spotted cat, *P. rubiginosus*	3	V. low	0	T	Poor
Fishing cat, *P. viverrinus*	2	V. low	0	T, E	Poor
African golden cat, *P. aurata*	2	V. low	0	S	Poor
Puma, *P. concolor*	5a(A)	V. high	T, H, P	A	Int.
Clouded leopard, *N. nebulosa*	3(A)	Low	0	T, E	Poor
Lion, *P. leo*	3(A)	V. high	T, H, P	S	Int.
Jaguar, *P. onca*	3(A)	Int.	T, H, P	A	Int.
Leopard, *P. pardus*	5a(A)	High	T, H, P	S, N, T	Int.
Tiger, *P. tigris*	2(A)	V. high	T, P	T	Int.
Marbled cat, *P. marmorata*	3	V. low	0	T, E	Poor
Snow leopard, *U. uncia*	2(A)	V. high	T, H, P	E	Good

1 The felid bibliography compiled by Foreman *et al.* (1988) is largely based on sources from North America, and contains many studies on captive animals in addition to articles from the popular press, but serves as a useful index to the relative degree of attention paid per species. In several cases, additional studies not included in the bibliography are accounted for. Very high = 200+ publications; High = 100-200; Intermediate = 50-100; Low = 15-50; Very low = <15.

2 F = Fur trade; T = Tourism; H = Trophy hunting; P = Problem animal. This column is an index of the importance of a species to national governments by way of its revenue-earning potential (or vice versa, in the case of species considered problem animals). Tourism revenue is attributed to a species only when it is likely that the majority of tourists visiting protected areas would be likely to specifically desire and expect to see that species.

3 S=Sub-Saharan Africa; N = North Africa and Southwest Asia; E = Eurasia; T = Tropical Asia; A = The Americas.

4 An indication of how well a species' diversity of habitat types or situation (e.g., inside vs. outside protected areas) is represented by studies conducted. Int. = Intermediate.

feasible and significant. Here research needs to play a major role. With appropriate advertising, tourists can be encouraged to visit reserves, public or private, that contain a rare and little-known (to the public) species of cat which they might see. However, cats are primarily nocturnal, and small cats are notoriously elusive and difficult to observe, particularly in densely vegetated environments (such as tropical rainforests, which are currently experiencing a boom in tourist interest). Without knowing more about the habits of these species, it will be impossible to create situations in which tourists would be likely to get a glimpse (and a photo) of these animals, let alone a background lecture on their ecology. Increasing tourist interest in the small cats would provide a tangible demonstration of these species' value to the governmental authorities charged with their conservation.

Potential economic value is of course not the only aspect of wild cats which requires further study. This chapter is concerned with those areas of scientific research which are important for cat conservation. Progress to date is reviewed, and areas where improvement is needed are highlighted. Both field and laboratory studies are covered. The study of captive animals is discussed in Chapter 5.

Field Studies

Field studies needed for cat species are discussed in four categories below, in order of increasing complexity. For all categories, the conservation importance of studying cat populations in settled or otherwise human-disturbed areas is emphasized. Progress to date is reviewed for two of the research topics, but data collected from natural history studies are given in the Species Accounts, and studies of human/carnivore conflicts are covered in Chapter 2.

Table 2
Species for Which Fewer than Three Adequate Studies of Natural History Have Been Done

Species	Percentage of Total Number of Species Occurring
Sub-Saharan Africa Black-footed cat, wildcat, African golden cat	38%
North Africa and Southwest Asia Cheetah, caracal, jungle cat, sand cat, wildcat, serval, leopard	100%
Eurasia Chinese mountain cat, manul	33%
Tropical Asia Bornean bay cat, Asiatic golden cat, jungle cat, leopard cat, flat-headed cat, rusty-spotted cat, fishing cat, clouded leopard, marbled cat	82%
The Americas Jaguarundi, oncilla, margay, pampas cat, Geoffroy's cat, kodkod, Andean mountain cat	58%

Natural History

Natural history represents the fundamental definition of species uniqueness in ecological terms. Natural history involves study of where (distribution, habitat selectivity) and how (diet, activity patterns, social organization) a species lives. Natural history studies do not always lend themselves to testing hypotheses, and for this reason have been very much neglected by the increasingly specialized students and scientists from the academic research community.

As shown in Table 2, a basic understanding of the biology and ecology of most of the small cats is lacking. This is especially true for the more vulnerable cats. However, even the common species have not been studied. Regionally, natural history research is most needed for the cats of north Africa and southwest Asia, tropical Asia, and Latin America. Study is lacking for those species which live in areas remote from urban civilization, such as high mountains, deserts, or tropical rain forest.

Why has science passed by so many of the cat species? In part, it is because cats are relatively difficult to study–they have evolved, in terms of both morphology and behavior, to avoid detection. Studying the ecology of a nocturnal cat would be practically impossible without the aid of radiotelemetry, and this technology has only become efficient and reliable since the 1980s. Also, in order to collar a cat, it must first be caught, and the literature of the Cat Specialist Group is replete with examples of the difficulty of live-trapping cats for study purposes.

Some individuals are notoriously trap-shy, while others are caught repeatedly. For example, Vaughan (in press) describes an attempt to mount a study of the ecology of three small cats in Costa Rica's La Selva Biological Station. Using chickens, mice, fish, and meat as bait, researchers ran a seven km trapline with 25 box traps, but after four months succeeded only in catching opossums and ants. On the other hand, J. Beltrán caught four ocelots in one day in southwestern Texas, where the species is actually quite rare (Anon. 1991c). One of five snow leopards radio-collared in western Nepal was caught five times (Jackson and Hillard 1986). While Rabinowitz (1992) caught the same leopard several times in western Thailand, Jenny (1993) had enormous problems catching just one in the Ivory Coast's Taï National Park. Problems in capture translate to problems in obtaining an adequate and balanced (in terms of sex and age) study sample.

Other ways in which cats do not lend themselves to convenient study include the length of time often required to gather sufficient data, when there is inevitably a variety of deadlines to meet which bear little relationship to the rhythms of the study population. Cats can be wide-ranging, and this complicates logistics. Cats are nocturnal, while humans are not. Also, even if radio-collared, study subjects are usually rarely, if ever, seen by the researcher. This is not only frustrating, but also potentially limits the data which can be collected.

However, all these setbacks apply equally to the northern hemisphere cats—the lynxes, the puma, the European wildcat—all of which have been relatively well-studied. Research on these cats has been largely funded by national governments, and it is safe to conclude that the main reason why most cats in other regions have not been studied is lack of funds. Most developing nations cannot allocate sufficient funds for basic research, and international conservation groups are less likely now than ever before to fund this type of work, preferring instead to support studies aimed at "biodiversity" rather than single species.

These obstacles are not insurmountable. Regarding the funding problem, this Action Plan is designed to highlight priorities within the cat world for both seekers of projects and donors of funds (Part III). With regard to the wider conservation benefits of research as well as to the difficulties of studying cats, attention should be drawn to the importance of including local people as project participants. Research needs are greatest in the developing countries. Involving local people as active participants in a study and providing training in the basics of field observation makes for a valuable transfer of technology and expertise to less developed areas. Conversely, local knowledge and "bush skills," which exist among traditional hunters and trappers can make a significant, but often overlooked, contribution to the success of a study — and may turn poachers into gamekeepers. With budgets for field studies being typically small, the hiring of local people can increase the size of a research team for a relatively low cost. Moreover, such action can be invaluable for shaping local perceptions regarding the value of their environment and the cats within. This has important long-term consequences for what happens after the principal researcher departs. If more well-trained and motivated individuals

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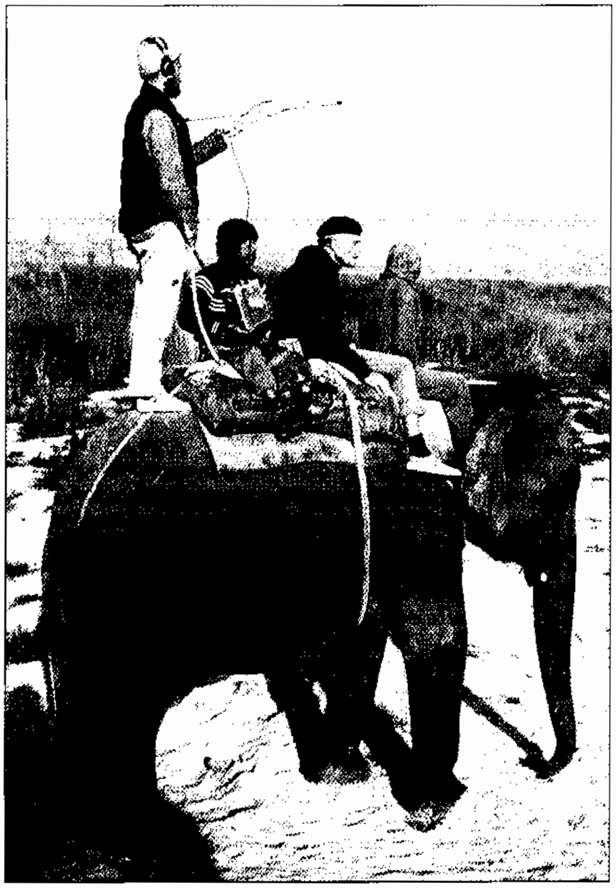
Radio-collaring a tiger in Nepal's Chitwan National Park during a long-term study of tiger ecology.



Monitoring the movements of a radio-collared tiger in Nepal's Chitwan National Park in order to establish its range.

around the world were actively to monitor, report on, and promote conservation of local cat populations, the benefits to international conservation would be enormous.

Natural history should be studied in both protected and disturbed habitats. The vast majority of studies have been done within protected areas, in part because results can then be evaluated in the light of a body of data collected on other aspects of the ecosystem, and theories and hypotheses can be more readily tested. However, it is increasingly recognized that few parks are large enough to constitute undisturbed nature. Indeed, most parks where research is an active and ongoing process are also actively managed, and the two complement each other. As disturbed and unprotected habitats make up the majority of the cats' ranges (Table 11, Chapter 1), the need to carry out more studies in these types of areas cannot be overstated.

It is important that researchers begin to assess the ways in which cats adjust to different forms of habitat modification and disturbance, and to identify "common denominators" which can be used to promote conservation outside protected areas. This type of research could broaden understanding of species distribution and habitat selection, and perhaps revise what are now rather pessimistic conceptions of species status.

For example, the flat-headed cat of tropical Asia is thought to be primarily tied to wetland environments, where it feeds on fish and crustaceans; at least 50% of wetland sites in the region are considered to be under moderate to high degrees of threat (Scott and Poole 1989, WCMC 1992). However, there are anecdotal reports of its presence in oil palm plantations in Malaysia, where it is thought to prey on rodents or even domestic poultry (M. Khan *in litt.* 1991). Similarly, the kodkod of Argentina and Chile is thought to be strongly tied to primary moist temperate forest, but it may do well in plantations of North American pine species where rodents are abundant (J. Rottman, pers. comm. in Melquist 1984). As a final example, the clouded leopard is another species traditionally thought to be tied to a particular habitat type—in this case primary tropical rainforest. However, it has been sighted in logged forest (Davies and Payne 1982, Rabinowitz *et al.* 1987, Santiapillai and Ashby 1988, M. Khan *in litt.* 1991), and may also make use of grassland and scrub habitats (Santiapillai and Ashby 1988, Dinerstein and Mehta 1989). Moreover, a cub was recovered from a tea plantation in India (Anon. 1992j). Are these animals dying in these habitats, or living there? Are such records isolated instances, or are the habitat requirements of these species more flexible than presumed? This information has important consequences for understanding species rarity and prioritization of conservation effort.

One reason why so few studies have been conducted of cats outside protected areas relates to why research is lacking on cats living in remote or inaccessible habitats. Practically speaking, in both situations establishing a workable research schedule can be a difficult and time-consuming process. Outside protected areas, it is necessary to work closely with a number of people who probably understand little of conservation (unlike park research staff), or may even be openly hostile to cats. Where cats are subject to persecution, they can be expected to have developed even greater secretive behaviors, magnifying the usual difficulties of capture and monitoring. Yet it is these cats for which study is of greatest importance. In terms of science, some aspects of behavior (i.e. activity patterns and predation) are likely to differ substantially from those inside protected areas, and understanding these differences is the key to appreciating the scope of species adaptability and evaluating probability of future survival (see, for example, the cheetah Species Account). Study results can also aid the development of strategies to reduce conflict between cats and people, and to manage habitat or human activity in ways that allow maintenance of cat populations at an appropriate level.

Biotelemetry equipment is indispensable to natural history studies of cats. L. Emmons (*in litt.* 1992) has emphasized the benefits of continuously following a collared animal (as opposed to taking periodic remote locations). She has applied this methodology to 15-20 mammal species (including ocelots: Emmons 1988) in primary tropical rain forest, one of the most challenging environments in which to study cats. Continuous follows, in all habitats, yield data on the following topics: exact circadian activity, pathway and distance moved per day, habitat use (quantitative), hunting tactics (directly or indirectly), diet and possibly kill rate, resting sites, encounters with other radio-tagged animals, and exact home range boundaries. Sampling periods should be at least several days long to allow the best understanding of how an animal really uses its ground, although this is time-consuming and limits the number of animals which can feasibly be included in a study. It is very important that the follower attempt to minimize disturbance by remaining at an appropriate distance behind the study animal and, in dense vegetation, using trails to avoid excessive noise which could "drive" the animal or scare away other species with which it would otherwise interact (e.g., prey). The most important aspect of this methodology, according to Emmons, is that it yields "a feeling for the animal: what it does and is, its general behavior, predictability, its personality. After a while of following through rain and shine, night and day, thick and thin, one begins to understand, from nothing but a disembodied signal, a great deal about the animal's moods and behavioral tendencies. Most species have highly characteristic or typical behavior patterns that are clear only after 2-5 days of following a given sex/age class. Males and females are often quite different in their behaviors."

Most cats, most of the time, are sympatric with other members of the family Felidae. The largest assemblages, or guilds, of felids occur in the tropical regions of Asia, the Americas, and Africa. The ways in which these species coexist, and the implications for relative abundance, have received comparatively little research attention. It is intriguing that in each of these tropical guilds, there are two species identical in jaw length, including the jaguarundi and margay in the Americas, the caracal and serval in Africa, and the Asiatic golden cat and fishing cat in southeast Asia (Kiltie 1984, Seidensticker and Lumpkin 1991). This also applies to the lion and tiger in Asia (D. Smith *in litt.* 1993), although the two are no longer sympatric, and it is doubtful that their ranges ever over-lapped to any significant extent. Jaw length, a measurement of maximum gape, has been shown to be strongly correlated

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Lynx trapped for radio-collaring in the Jura Mountains, Switzerland, during a study of a reintroduced population.

with modal prey size (Kiltie 1984). Although these pairs of species may exploit similar-sized prey, they select different habitats. The serval and fishing cat prefer wetlands, while the margay appears to be the most arboreal of the American cats; the three others are more generalist in their use of habitat. The fact that for each of these pairs of species, one is patterned and the other plain, may reflect this difference (Seidensticker and Lumpkin 1991). The spotted morph of the Asiatic golden cat has been most commonly reported from China, where the fishing cat does not occur.

Field studies have indicated that different sized cats tend to exploit different sized prey (Seidensticker 1976, Bertram 1982, Emmons 1987, Koehler and Hornocker 1991). Sympatric cat species may also exploit different patches of habitat (Seidensticker 1976, Parker *et al.* 1983, Emmons 1987, Koehler and Hornocker 1991, Rabinowitz 1989), or the same habitat at different times (Bertram 1982, Rabinowitz and Nottingham 1986). To varying degrees, these factors also determine ecological separation where cats are sympatric with other predators (Schaller 1972, Johnsingh 1983, Leopold and Krausman 1986, Konecny 1989, Sunquist *et al.* 1989, Rabinowitz and Walker 1991, Mills and Biggs 1993, Johnson *et al.* in prep.).

The differences in prey and habitat selectivity between sympatric cat species, and possibly other predators, are a priority for study because of the rapid rate of habitat modification. To what extent will this increase interspecific competition, and benefit one species at the expense of another? The largest felid guilds occur in tropical rainforest, the habitat type undergoing the highest rate of loss, and the small cats within these guilds are very close in size. How do they co-exist? Ecological separation in these felid communities can be investigated most efficiently by having a small team carry out basic natural history studies in the same study area at the same time, with each member concentrating on a different species.

Population Status Surveys

Status surveys vary in rigor, depending on their objective, from confirmation of species presence to estimation of density or total population size. Repeated surveys allow monitoring of population dynamics. Cats, however, are notoriously difficult to count (e.g., Bertram 1979). Traditional census techniques, such as transect counts or mark-recapture studies, tend to fail when applied to cats. The irregular, individualized, and cryptic behavior and movements of cats violate the basic assumption of both methods, which is that sighting (or resighting/recapture) is predictable. More reliable techniques need to be developed which can be standardized so that results obtained by different observers from different areas are comparable. An important example of a move in the right direction is the Snow Leopard International Management System (SLIMS), a protocol for standardized field survey techniques under development at the International Snow

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Russian and American researchers confer in the Russian Far East, where the Amur (Siberian) tiger is threatened by poaching.

Leopard Trust (R. Jackson, pers. comm. 1993).

Techniques which have been used to survey cat populations are described below. The first type, presence or absence surveys, is important for mapping species distribution, including the identification of sub-populations. The second type, which yields density estimates, is necessary for understanding population status. It is a long-term goal of the Cat Specialist Group to stimulate, conduct, collect and synthesize local status surveys into a Geographic Information System (GIS) database to map the meta-population of each species. This would greatly improve the ability of the Cat Specialist Group to focus attention and resources on threatened populations. There is a long way to go toward achieving this goal, but it is a feasible one if the financial support necessary to refine survey techniques and then apply them strategically is forthcoming.

Presence or Absence Surveys

This type of survey seeks to confirm whether a particular species is present in an area and provide a rough "guesstimate" of its status—rare, common, threatened, decreasing, etc. The usual approach is to access the knowledge of national and local authorities, experts, and residents (Myers 1975, 1976, Teer and Swank 1977, Eaton 1978, Melquist 1984, Hamilton 1986a,b, Tello 1986a, b, Rabinowitz *et al.* 1987, Swank and Teer 1987, Martin and de Meulenaer 1988, Rabinowitz 1988, Gros 1990, Tischendorf 1991, Tilson 1992a, Salter 1993). Interviews can also be conducted more intensively in areas which potentially harbor important sub-populations. Local people, however, may not necessarily discriminate between cat species, particularly the smaller ones. Ideally, but especially in these cases, interviews should be combined with confirmative survey techniques that look for sign or individual animals (e.g., Koehler 1991, Rabinowitz 1993).

Both cats and people tend to use trails, and presence or absence can often be established on the basis of sign found alongside them, including footprints, feces, scrapes (for some of the larger cats), and tree "scratching posts" (Stuart and Stuart 1992b). When several similar-sized species are found in the same area, however, it is preferable to use camera photo-traps. Triggered by a tripwire, a pressure pad (which can be sensitized to a minimum weight), or an infrared beam, this method is relatively simple, inexpensive, and requires low input and maintenance (Joslin 1988, Jackson and Hillard 1986, Stuart and Stuart 1991, Griffiths and van Schaik 1993b). Other methods involve active attempts to attract cats: playing tape-recordings of prey sounds (e.g., goat bleating: P. Stander, pers. comm.) or sounds of feeding (Smuts *et al.* 1987), scent posts, and bait (live or dead), which can be accompanied by either a photo or sand trap (for recording track impressions), or a hidden observer.

Judicious use of maps can be very useful for more efficiently assessing the distribution of sub-populations in fragmented habitat. In particular, Smith *et al.* (1987a) emphasized the utility of GIS, which consist of computerized data bases that perform map overlays. Maps which show vegetation, settlement, roads, topographic features, etc.—all physical features which affect cat distribution—can be used to identify areas likely to harbor important sub-populations. Presence or absence in these areas can then be evaluated by confirmative surveys. For example, Van Dyke *et al.* (1986b) have suggested that consistent track searches along dirt roads by competent trackers should reliably detect presence or absence of pumas in areas of suitable habitat in the eastern United States (where they are believed to have been eradicated by the late 1800s).

Estimating Density

Only detailed study, lasting several years and using biotelemetry, within a relatively small area (for big cats, generally not more than several thousand km^2; for small cats, considerably less) is likely to yield an accurate estimate of population size. In such situations, researchers can be reasonably confident of their ability to identify all animals resident within the area, and to distinguish transients. All other methods and estimates are less intensive, but also less reliable.

Estimating the size of a larger population is generally done by taking a density estimate as described above, expressed in terms of the number of resident adults per unit area, and extrapolating it over other areas of similar habitat. However, Schonewald-Cox *et al.* (1991) reviewed 214 population censuses of carnivores, and found that surveys over relatively large areas tended to yield lower density estimates. They concluded that extrapolating site-specific densities over larger areas probably leads to overestimation of population size. The reason for decreasing density with increasing survey scale is probably a reflection of the patchiness of suitable or optimal habitat over larger areas (Schonewald-Cox *et al.* 1991). In addition, researchers often select study sites which support relatively high numbers of study animals, and density estimates resulting from small-scale surveys in such areas of optimal habitat would yield overestimates if applied to less optimal areas. Finally, for carnivores with large home ranges relative to study area size, more accurate density estimates may result if some animals are included as only proportionally resident to account for parts of their home ranges which may lie outside the study area (Garshelis 1992).

The various techniques used to establish presence or absence can also be used indirectly to estimate density—usually in relative terms (compared to other locations or a previous survey) rather than absolute (a numerical estimate of population size). All have drawbacks which compromise their accuracy.

Several studies have investigated whether there is a direct relationship between population density and sign (tracks, feces, scrapes) frequency (Stephenson 1986, Van Dyke *et al.* 1986b, Ahlborn and Jackson 1988, Van Sickle and Lindzey 1992). Transect surveys can be flown (in areas of snowfall), driven (along dirt roads) or walked (along trails), and it is hoped that counting signs along one or both sides can provide a simple index to population abundance. These studies all included intensive radiotelemetry work to provide independent confirmation of density estimates based on sign alone. Although all found some evidence for a relationship, in practice sign frequency is unlikely to yield more than an indication of relative abundance (e.g., high or low density population), and probably cannot be translated to a numerical estimate of population size.

The premise of the sign transect method is that a population at high density leaves more detectable signs than a population at low density, but there are numerous variables, difficult to correct for, which affect how frequently signs are deposited. For example, with regard to track frequency, some trails are more heavily used than others because of their physical characteristics (i.e., located along watercourses). Also, the same individual may repeatedly cross a trail. On the other hand, transects may be situated so that they do not properly sample the population. Theoretically, an accurate count would require that transects should bisect each resident individual's home range but, of course, this is impossible in practice (Van Sickle and Lindzey 1992).

Scrapes and scats are also not necessarily randomly distributed because they are an important means of intraspecific communication (Leyhausen and Wolff 1959, Hornocker 1969). To increase the likelihood of the message reaching a conspecific, sign may be concentrated at trail intersections (Robinson and Delibes 1988), along travel corridors such as ridgetops (Seidensticker *et al.* 1973), in small patches of mutually used prime habitat (Ahlborn and Jackson 1988, Fox *et al.* 1991a), within contact zones between territories (Seidensticker *et al.* 1973, Smith *et al.* 1988, Rabinowitz 1989), or at communication centers, such as the "marking trees" exploited by Namibian ranchers to live-trap large numbers of cheetah (McVittie 1979, L. Marker-Kraus, pers. comm.). Ahlborn and Jackson (1988) found that snow leopards increased their marking behavior when a female went into estrus. Similarly, Corbett (1979) showed that a resident male European wildcat increased his rate of spray-marking tenfold when a transient male ventured into his home range, and overmarked all of the intruder's scent marks. As marking behavior has an important social function, it is likely that it would be increased in high density populations. If frequency counts made in such situations were used as an index, abundance of low density populations could be underestimated (Fox *et al.* 1991a).

A variant of the sign transect is the scent-station survey, widely used by management agencies in the United States to census bobcats. This survey technique is preferred because it provides uniformity of methodology, repeatability, and cost efficiency (e.g., papers in Blum and Escherich 1979). Scent stations consist of an attractant scent (usually a plaster disc saturated with various synthetic fatty acids) surrounded by an appropriate tracking substrate, such as lime ($CaCO_3$). Stations are widely spaced along transect lines so as to minimize multiple visits by the same individual. Several studies have monitored population size through radiotelemetry and intensive study, and then evaluated the ability of scent-station surveys to accurately reflect population status (Rust 1980, Conner *et al.* 1983, Diefenbach 1992). Conner *et al.* (1983) found a good correlation, Rust (1980) found none, and Diefenbach (1992) suggests that only multiple surveys can detect even relatively large changes (>30%) in high density populations. While he recommends that a minimum of four per year be conducted, agencies generally survey only once per year (Johnson and Pelton 1981). Bobcat visitation rates to scent stations tend to be low (often just 2-5% of posts visited), but Diefenbach (1992) cautions against attempts to increase visitation because this will statistically increase variation in resulting estimates.

Another sign survey technique is used by the Indian government in its periodic tiger censuses, which attempt to quantify actual population size based on track uniqueness. Pugmark outlines are traced onto glass plates in the field, and the assumption is that differences between individual animals will be consistently detectable (Panwar 1979, Sale and Berkmüller 1988). This technique has been criticized by Karanth (1993b), who tested six experienced Indian wildlife managers by making 33 tracings of the pugmarks of four captive tigers on two different soil substrates. While 75% of the respondents were able to correctly identify the sex of the tiger, performance was much poorer on establishing whether the marks were made by front, rear, and left or right paws, and worst of all on estimating the total number of tigers responsible for the pugmarks. Estimates were 6, 7, 13, 23, and 24 tigers– all overestimates, the highest by as much as 600%.

However, Sale and Berkmüller (1988) emphasize that, with intensive surveys covering a relatively small area, reasonably accurate information can be gathered regarding the population's age and sex structure, spatial organization, and abundance. The tracking abilities of skilled hunters, particularly those from hunter-gatherer societies, such as the Bushmen of southern Africa, are highly developed. Such people can, with practice, learn to recognize the spoor of individual animals (P. Stander, pers. comm.). Scientists, however, usually cannot, and in Utah they surgically removed a rear toe from each adult resident puma in their study area to aid tracking and population monitor-

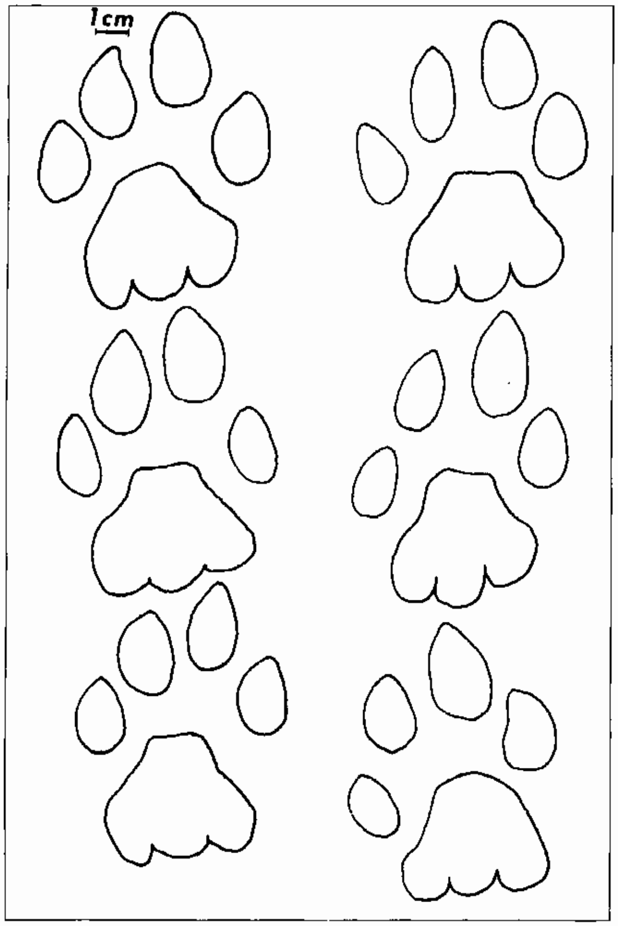


Figure 1. Can you identify the three left rear tracks made by the same puma? None of 52 participants at the Third Mountain Lion Workshop in Arizona were able to. From four pumas, the three tracks in the right column were left by one, and the three tracks in the left column were left by three others. Measurements from these tracks were included in multiple group discriminant analysis and all tracks were correctly grouped. Source: Smallwood and Fitzhugh (1993).

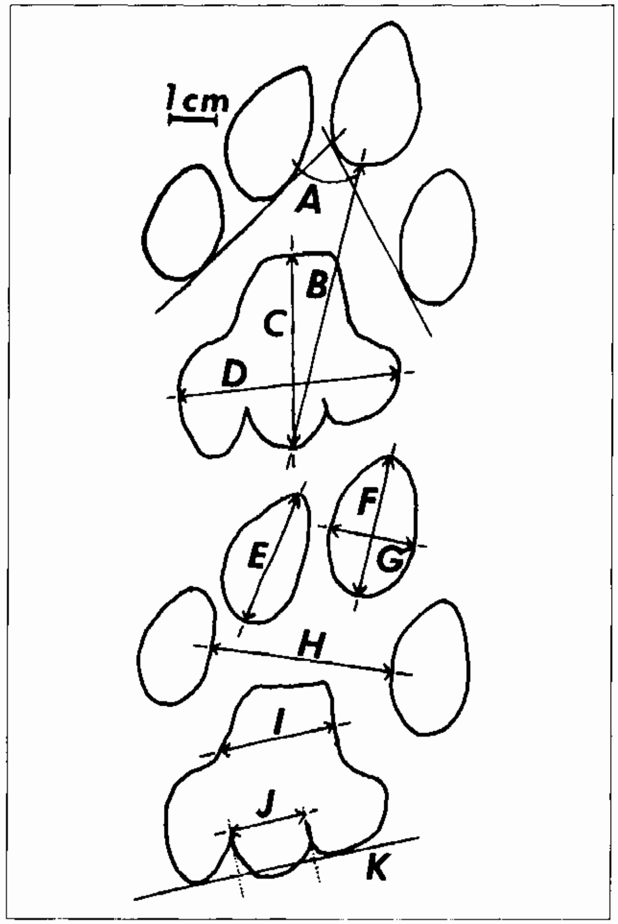


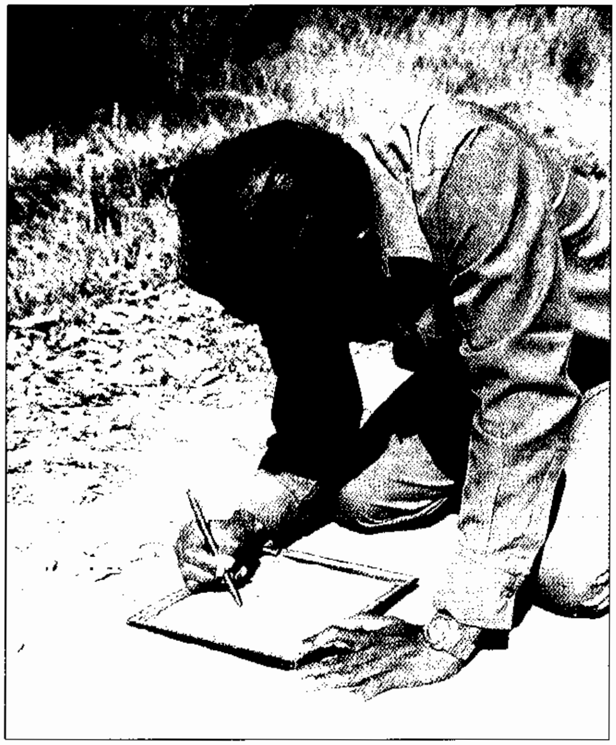
Figure 2. Track measurements used to identify nine mountain lions: A. Angle between toes; B. Heel to lead toe length; C. Heel length; D. Heel width; E. Third toe length; F. Lead toe length; G. Lead toe width; H. Outer toes spread; I. Midline width, a parallel line 25 mm from the baseline (see K); J. Heel lobe width; and K. Baseline used to draw midline. Source: Smallwood and Fitzhugh (1993).

ing (Lindzey *et al.* 1992).

Recently Smallwood and Fitzhugh (1993) were able to distinguish tracks of different pumas reliably by using multiple group discriminant analysis of standardized pugmark measurements. While qualitative identification was seldom correct (Fig. 1), and no single pugmark measurement proved sufficient, use of up to eight different measurements allowed 100% correct identification (Fig. 2).

Individual animals can also be recognized from distinctive markings, so that camera photo-traps, if distributed widely through an area, can be used to generate rough estimates of abundance, either through direct counts of individuals or mark-recapture techniques. Tigers can be identified on the basis of the stripe pattern above the eye (Schaller 1967) or on the cheek (McDougal 1977). Leopards (Bertram 1978, Miththapala *et al.* 1989), snow leopards (Hillard 1989), and cheetahs (Eaton 1970, Frame and Frame 1981, Caro and Collins 1986, Bowland 1993) have been identified on the basis of facial spot patterns and, for the cheetah, tail tip band patterns, which can also be used as an index of individual relatedness (Caro and Durrant 1991). Lions can be identified by unique patterns of whisker vibrissae spots (Pennycuick and Rudnai 1970).

Species-specific behavior can also be exploited to attract animals for counting or marking. Smuts *et al.* (1977) dragged large carcass baits to lay down scent trails, then staked out the bait and played tape-recorded sounds of feeding at high volume to attract lions for immobilization. They succeeded in capturing and marking 409 lions in the space of 79 nights (with two teams working each



Tracing the pugmark of a tiger during an Indian census.

night). Abundance of lions has also been estimated by having a team of widely spaced observers listen for roars, which can be heard at distances of 4-8 km (Rodgers 1974, Packer 1990).

In their suggestions for future directions for research into large carnivore ecology, Quigley and Hornocker (1992: 1093) emphasized that work to improve census techniques must continue, despite "the nature of the beast [being] against us with these secretive animals." Much effort has already gone into this area of research but, as Schonewald-Cox *et al.* (1991) pointed out, the results of many status surveys are contained in unpublished reports which are often difficult to access. Better communication between researchers working in different environments would probably not only aid improvement and standardization of survey techniques, but also help genesis and synthesis of ideas. To this end, establishing the Cat Conservation Center of the Cat Specialist Group (see Part III) would be a significant step forward.

The current tiger poaching crisis is a prime example of why accurate census techniques are of fundamental importance. Official tiger censuses in India put the population at 4,334 in 1989, and 3,750 in 1993 (Nath 1994), thus suggesting that some 600 tigers may have been lost in the interval, about 20% of the population. Yet the 1989 estimate was widely considered exaggerated (Karanth 1993b), while unofficial analysis of the 1993 data suggests that there could be as few as 2,750 tigers in the country (V. Thapar, pers. comm. 1994). Just as it is unclear to what degree tigers have increased in India since the initiation of Project Tiger in 1973 (Karanth 1993b), it is also difficult to say to what degree tiger populations have recently declined. If reliable gauges of tiger abundance cannot be worked out, it will be impossible to determine whether measures such as tiger bone trade bans are effectively reducing tiger losses to poaching.

Long-term Studies

Long-term studies have been the key to insights into felid biology and ecology. For example, the long-term study of lions in the Serengeti has provided the data for a long and continuing exploration of why lions are social (and why other felids are not) (Schaller 1972, Caroco and Wolf 1975, Bertram 1978, Bygott *et al.* 1979, Packer 1986, Clark 1987, Packer and Ruttan 1988, Caro 1989, Packer *et al.* 1990). The study of a puma population in Idaho helped to define solitary felid social organization, and showed the importance of territoriality in limiting population size (Hornocker 1969, Seidensticker *et al.* 1973).

Moreover, long-term studies of cats have shed illumination on issues of great relevance to their conservation. Three puma studies in North America have explored the effects of human regulation of puma populations. Ross and Jalkotzy (1992) studied the dynamics of a hunted population of pumas in Alberta. Two other studies have employed an experimental approach: the effects of sport hunting and predator control operations are being simulated by removing animals of the target sex and age classes from well-studied protected populations (Lindzey *et al.* 1992, Sweanor and Logan 1992). The "hunted" animals are actually released elsewhere, so that reintroduction of pumas (of potential interest for eastern North America) can also be studied (Hornocker 1992). The well-documented history of the numerous problems faced by the small Florida panther population illustrates what is likely to happen even to protected big cats in settled areas, unless land-use planning takes their needs into account (Maehr 1990, Maehr *et al.* 1991, Logan *et al.* 1993, Roelke *et al.* 1993).

In the tropical zone, cheetahs in the Serengeti have been studied for over 20 years (Schaller 1972, Eaton 1974, Frame and Frame 1981, Caro 1994, S. Durant in prep.), and researchers have tracked a population decline, concurrent with increases in the lion and spotted hyaena populations, that challenges traditional conservation strategies based on protected areas. Data gathered over 15 years on tigers in Nepal's Chitwan National Park have made this population the best case study for the difficulties of conserving a population of large, dangerous cats in an insular reserve surrounded by dense human settlement (McDougal 1977, Sunquist 1981, Smith 1984, Smith *et al.* 1987a, Smith and McDougal 1991). Unpredictable environmental events which have befallen the insular population of lions in Tanzania's Ngorongoro Crater demonstrate the vulnerability of small isolated populations to these factors (Packer *et al.* 1991b).

It is not surprising that there have been only a few long-term studies of the smaller cats, and that these have focused on the lynxes. Reintroduced populations of lynx have been studied in Switzerland since 1983 (Haller and Breitenmoser 1986, Breitenmoser and Haller 1987, Kaczensky 1991, Breitenmoser and Baettig 1992, Haller 1992, Breitenmoser *et al.* 1993, Breitenmoser and Haller 1993). Long-term study of the Iberian lynx, the world's most vulnerable cat species, has made it possible for researchers to identify the causes of population decline; to propose corrective measures, and to mount an effort to accurately map out extant sub-populations (Delibes 1979, 1980, Beltrán *et al.* 1987, Rodriguez and Delibes 1990, 1992, Palomares *et al.* 1991, ICONA 1992). Even though there are long observation series data on the Canada lynx, due to strong research interest in its close relationship with cyclic snowshoe hare populations, no study has yet focused on the social dynamics that occur within a single population over an entire hare cycle (Breitenmoser *et al.* 1993b). In terms of lynx conservation, understanding of these dynamics is critical for refining harvest regulations so that commercial trapping is not unsustainable during cyclic population lows (see discussion in Chapter 4, Trade).

It is important that long-term studies remain focused on population dynamics. Clear understanding of how a population is organized—which animals are actually siring offspring and how many over a lifetime, how far the young disperse, how many young are surviving to breeding age—can only come about through long-term study that focuses closely on a specific population. Chepko-Sade *et al.* (1987) provide useful guidelines for field collection and presentation of data necessary to calculate the effective size of the study population (see below for discussion). The results of focused, long-term studies provide a baseline against which other populations can be measured, and an index which can be used to estimate the status and viability of unstudied populations with greater reliability.

Long-term studies are needed to identify the roles played by cats within ecosystems. It is possible that the large cats, in particular, may be keystone species. Terborgh (1988) suggests that jaguar and puma predation on large seed-eating neotropical herbivores (peccary, paca, agouti) ultimately influences tree species composition of tropical forests.

While studies too numerous to list here have quantified cats' offtake of prey populations, there has been no focused long-term research on whether cat predation con-

Peter Jackson

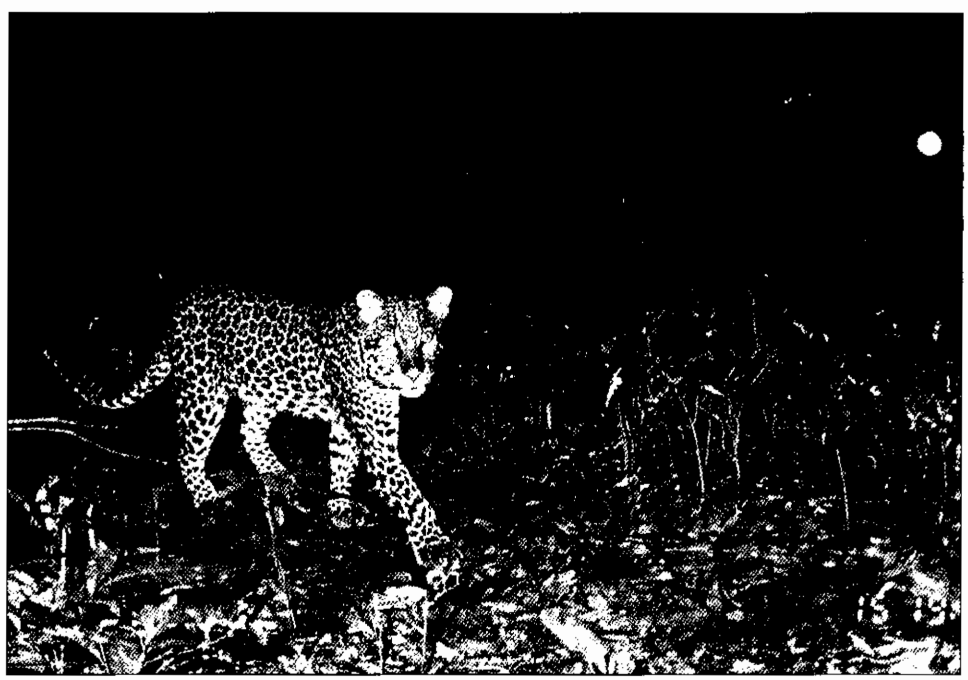
Measuring tiger stride during an Indian census.

trols these populations (Quigley and Hornocker 1992). Cats have traditionally been and still are viewed by many people as decimators of game. The practice of attempting to remove all predators from reserves continued well into the 20th century in many countries, and today predator control is probably the main reason why cats continue to be eradicated outside protected areas. However, generally speaking, current thinking holds that predation alone does not cause prey declines, but can accelerate declines caused by other factors (e.g., poor food base, or disease) (Ginsburg and MacDonald 1990). The decline could continue to the point where an insufficient prey base reduces the number of predators, allowing the prey population to recover and increase. Alternatively, the system could stabilize with a reduced prey base until environmental conditions are such that favor prey increase. Basically, the nature of predator-prey relationships appears to be a sort of fluctuating, or dynamic, equilibrium. The degree and rate of change are highly dependent on local conditions.

Human impact can have a significant influence on the dynamics of predator-prey relationships. Hunting by humans can dramatically alter the species composition of habitat which remains otherwise relatively undisturbed. Jorgenson and Redford (1993) showed that pumas, jaguars, and subsistence hunters in Latin America tend to take the same mammalian prey species. People may scavenge wild prey killed by big cats (Johnsingh 1983, Thomas 1990), and cats are often chased off their livestock kills (Joslin 1973, Rashid and David 1992, Oli *et al.* in press). Since big cats will typically feed off a large carcass for several days, scavenging by humans should lead to an increase in cats' kill rates.

Habitat fragmentation could also strongly affect the amplitude of local predator-prey dynamics. When prey species decline due to environmental conditions in an isolated habitat block, both immigration of new prey animals and emigration of predators seeking better food supply can be impeded. In Africa, fences have proved to be significant barriers to some migratory ungulates, leading to population declines (Owen and Owen 1980, Williamson and Williamson 1985, Whyte and Joubert 1988). Within such confines, and under certain environmental conditions, there is a real risk that predation could drive key prey species to the verge of extinction. This was the justification for the decision to cull lions from part of Kruger National Park in the 1970s, but the effort was unsuccessful—the population was replaced by immigrant lions, and grew rapidly under low density conditions (Smuts 1982).

Ecosystems are complex and dynamic. Only after 30 years of study has it been possible to elucidate the characteristics of a relatively simple predator-prey system: wolves and moose on Lake Michigan's Isle Royale (Peterson and Page 1988). Similarly, the cyclic decline of snowshoe hare populations in Canada is a regular phenomenon which has been the focus of a prodigious amount of research attention, yet even after decades of studies,



David Jenny

Leopard photographed by a camera trap in the Taï National Park, Ivory Coast. The trigger-beam reflector can be seen (top right).

researchers are still unable to determine whether the initial decline is sparked by the hares themselves (through their interaction with their food resource base) or by their predators (Krebs *et al.* 1992). It may not be possible to apply the lessons of long-terms studies from one area to another. Thus, long-term studies of the role of cats within ecosystems will ultimately have greatest utility for the management authority of the study area, and are most significant for high priority protected areas holding key populations of species of conservation concern. These studies should also include the interaction between the study population and the environment immediately outside the confines of the protected area.

Resolving Conflicts with People

Conflict between cat and human interests has been discussed in detail in Chapters 1 and 2. This is a key issue in cat conservation, and there is a need to greatly expand applied research, with the explicit objective of developing and implementing workable solutions. The larger cats, particularly those of Categories 1-3, are of top priority for this type of field work. The topic is multi-disclipinary, and research will entail much more than quantification of the amount of livestock in a predator's diet. There are unlikely to be simple, universal prescriptions for ways in which cats and people can coexist. However, broad themes for investigation include improvement of land use planning and livestock management, institution of appropriate controls where cats or their prey species are being unsustainably hunted, and development of economic use options involving cats, including tourism and sport hunting.

It is with this final topic that study of cats reaches peak complexity. The resolution of human/predator conflicts straddles the two worlds of conservation and development, which are often, but not of necessity, in opposition. This type of research will require the largest amount of funds, the largest number of participants, the greatest degree of cooperation between people of possibly disparate aims, and thus the largest possible reserve of patience and perseverance. It is not necessarily the most scientific or the most complex. In human-modified areas, situations change more quickly and less predictably than in protected areas. Trying out a possible solution without having conducted a full study to evaluate its potential impact, and then adapting management to the results, is most appropriate for work on human/predator conflicts (Stander 1993). In such situations, where no action means no progress, there is more to gain and less to lose.

This topic returns full circle to the beginning of this chapter. Research efforts have been heavily skewed toward those species which either generate revenue or consume it as problem animals. People destroy cats, either deliberately or indirectly through habitat alteration and removal of prey species, because cats are seen as either being valueless or, worse, parasites. For cat conservation to succeed, two very important goals are to make wild cat populations more valuable to both local residents and national authorities, and to develop solutions which minimize revenue loss to problem animals. It is urgent that the horizons of field research on cats be broadened beyond ecology to include socioeconomics.

Laboratory-based Research

Intraspecific Diversity and Systematics: The Question of Subspecies

Review of species status (Part I) shows that the crisis at hand for wild cats is genetic erosion within species, rather than loss of species. No species are at present threatened with imminent extinction, but populations are being extirpated. However, while there is general agreement among felid taxonomists regarding recognition of cat species, confusion reigns on the subject of cat subspecies (see Appendix 1 for a listing). For example, in its action plan, the Felid Taxon Advisory Group of the American Zoo and Aquarium Association (AZA) called for taxonomic research aimed at validation of subspecific status for 235 out of 259 taxa recognized by the group (Wildt *et al.* 1992a: 183).

It appears that too many subspecies have been described on the basis of too little evidence (Anon. 1991d). For example, while 12 subspecies of bobcat have been recognized within the United States (Samson 1979, Hall 1981), Read (1981) and Werdelin (1981) have pointed to the absence of geographic barriers, and suggested that most of these subspecies are probably invalid. Miththapala (1992: 12), after carefully documenting the different types of imprecision in description of leopard subspecies, notes that "almost all...were defined during the late 19th and early 20th century. During this time, it was not uncommon for western naturalists to travel to their colonies in the tropics on hunting trips and scientific expeditions, bring back large collections, and have a subspecies named after themselves." She presents preliminary evidence to indicate that leopard subspecies should be subsumed under broad regional types separated by major geographic barriers, making the best case for treating all leopards of sub-Saharan Africa as a single subspecies. On the other hand, A. Kitchener (*in litt.* 1993) has suggested that the snow leopard, for which two subspecies have been described (Stroganov 1962) but are not generally recognized (e.g., Hemmer 1972, Wildt *et al.* 1992a), is a prime candidate for subspeciation due to the insular and patchy

Box 1
Subspecies Identification Incorporating Molecular Genetics
by Stephen J. O'Brien

To resolve the issue of cat subspecies and make them a component of cat conservation, it is first important to agree upon the basis for species and subspecies classification. My own version based on a collaboration with Professor Ernst Mayr follows (O'Brien and Mayr 1991).

In 1940, Mayr proposed the Biological Species Concept (BSC) that defined a species as "a group of actually or potentially interbreeding populations that are reproductively isolated from other such groups" (Mayr 1940, 1963). Reproductive isolation, the primary component of the BSC, refers to the heritable tendency of distinct species to avoid gene flow or interbreeding even when they are brought into physical contact in nature. In clarifying this notion, Mayr (1970) noted that most species occupy distinct ecological niches, and that this ecological distinctiveness is the keystone of evolution. Although various alternative species concepts and criticisms have appeared (Sokal and Crovello 1970, Cracraft 1983, Paterson 1985, McKitrick and Zink 1988, Templeton 1989, Wiley 1990), the BSC has survived the test of time and weathered the assault with its major components affirmed.

A major strength of the BSC is that it reflects the occurrence in natural situations of the irreversible process of speciation. It emphasizes reproductive isolation as the sole discriminator of species as whole entities, but acknowledges the occasional production of hybrid individuals, or even hybrid zones. There are numerous examples of stable hybrid zones that appear to be geographically balanced by selective disadvantages of hybrids vs. dispersal of individuals from the contact zone (Barton and Hewitt 1985, 1989). The distinction here is that natural occurrences of hybrid individuals or hybrid zones between good species do not disintegrate the genetic integrity of the species as a whole, while hybridizations between subspecies normally do produce gene flow and genetic mixing. Reproductive isolation in nature provides an effective protective device for well integrated genotypes. Importantly, the BSC acknowledges the existence of appreciable genetic diversity within species that is often partitioned geographically (or temporally) by population subdivision into subspecies, ordinarily under conditions of allopatry (geographical separation). Groups of such genetically distinguishable but still reproductively compatible races are subspecies that together would comprise a polytypic species.

Classically, a subspecies has been defined as "a geographically defined aggregate of local populations which differ taxonomically from other subdivisions of the species" (Mayr 1940, 1963, 1970). More recently, Avise and Ball (1990) have argued that subspecies identification should be based on genetic traits. In an attempt to provide formal criteria for subspecies classification, O'Brien and Mayr (1991) suggest that members of a subspecies share: (1) a unique geographic range or habitat; (2) a group of phylogenetically concordant phenotypic characters that can be described; (3) a unique natural history relative to other subdivisions of the species. Because they are below the species level, different subspecies are reproductively compatible. They will normally be allopatric (i.e., the reproductive barriers are geographic), and they will exhibit recognizable phylogenetic partitioning, because of the time-dependent accumulation of genetic difference in the absence of gene flow. Most subspecies will be monophyletic; however, they may also derive from ancestral subspecies hybridization.

O'Brien and Mayr (1991) agree with H. Hemmer (in Anon. 1991d) that the concept of a subspecies as a static unit is outdated. According to O'Brien and Mayr (1991), subspecies can: (1) go extinct; (2) exchange genes with another subspecies and become a new "mixed" subspecies; (3) by genetic drift, selection, subdivision, or other demographic processes change its genetic character over time to become one or more new subspecies; (4) if effectively isolated, become a new species by acquiring genetic isolating mechanisms; and (5) remain unchanged. It is not possible to know which subspecies will become new species, but they all have this potential. Moreover, as the time of allopatry increases, the probability of genetic differentiation increases, and genetic differentiation is likely to include ecologically relevant adaptations. The possibility that

Continued on next page

subspecies carry such adaptations, coupled with their potential to become new species, are two compelling reasons for affording them protection against extinction.

We are presently revisiting subspeciation in the puma (30 classically described subspecies) and leopards (29 classically described subspecies), using a suite of molecular methodologies. Following the recommendation of Avise and Ball (1990), we are searching for discrete concordant genetic characters that are unique to and diagnostic for a subspecies. When comparing several individuals from a classically described subspecies, we have encountered four ranked levels of distinction: (1) existence of one or more fixed genetic characters or genotypes that are present in all members of one subspecies, but not in any other; (2) the presence of a polymorphic but uniquely derived genetic character genotype in some, but not all, individuals of a subspecies, but not found in any other subspecies; (3) a distinct gene frequency of one or more polymorphic genetic characters that is distinct from allelic frequencies of the same polymorphic characters in other subspecies; and (4) geographic isolation but absence of recognizable genetic differentiation. In our view, the presence of category 1 distinction is sufficient to affirm formal subspecies classification, while anything less (categories 2-4) reflect so recent a partition as to not support subspecies designation.

nature of its high mountain habitat.

In order to conserve intraspecific diversity, there must first be agreement about how to define a subspecies (see Box), and then identification of where subspecies exist. While there have, in fact, been a number of papers written on felid subspeciation (e.g., Pocock 1951, Weigel 1961, Herrington 1987, to name only a few), standardized criteria have not been applied. Once the identification criteria for subspecies have been agreed upon, efforts to define subspecies and map their current geographic range should be prioritized according to either global or regional species vulnerability. In tropical Asia, investigation of the taxonomic status of the Iriomote cat is of high priority, and an exception to this rule. The Iriomote cat is the only felid taxon whose specific vs. subspecific (leopard cat: Category 5b) status is a matter of strong debate (see Species Account).

Identifying felid subspecies and mapping their distribution will require a high degree of cooperation between field biologists, systematists, geneticists, and museum and zoo personnel. Genetics and morphology can be studied from zoo animals and museum specimens. Specimens, however, are scattered among a number of museums, and there is no centralized database listing felid specimens held by the world's various museums. Collection of samples from captive animals also poses problems. First, as shown in Table 4, Chapter 5, over 60% of the officially catalogued captive populations of 20 cat species consist of generic animals, or animals of unknown origin. Second, captive-bred animals are likely to be poor representatives of the genetic diversity found in wild populations. For example, Miththapala (1992) notes that it was difficult to analyze the validity of the South China leopard on the basis of samples taken from captive animals: the population had been deliberately inbred over several generations to maintain melanism.

Samples from wild animals are of critical importance to the task of mapping intraspecific diversity. This chapter calls for a major increase in research effort to map species meta-populations. In the process of carrying out surveys, researchers should coordinate with systematists and molecular biologists to ensure that the biological samples necessary to evaluate population uniqueness are collected. Appendix 2 contains a field protocol for collection and storage of such samples.

Genetics

Molecular research can address five important questions relevant to conservation: (1) the uniqueness of species relative to others within the same genus or higher taxonomic unit; (2) the interrelatedness of species sub-populations, leading to understanding of historic patterns of movement and the degree of gene flow; (3) the amount of genetic diversity within a species, subspecies, or population; (4) the degree of hybridization between individuals from the same or closely related species; and (5) the breeding structure of a population (Wayne *et al.* 1992). This field has seen great progress over the 1980s in both technique and application. Use of diagnostic genetic fragments to determine degree of relatedness between individuals, known as DNA fingerprinting, was only recently developed (Jeffreys *et al.* 1985), and has been rapidly improved and simplified (reviewed by Wayne *et al.* 1992). One substantial improvement was the development of polymerase chain reaction (PCR), also in 1985, which permits multiple copies of genetic material to be made from just a minute

Table 3
Genetic Research: Questions, Applicable Techniques, and Examples of Studies of Felids (modified from Wayne *et al.* [1992])

Questions	Techniques [1]			
	Karyology	Allozymes	mtDNA	VNTR
1. Phylogenetic distinction	X	X	X	?
2. Phylogeographic history	—	X	X	X
3. Genetic variability	—	X	X	X
4. Hybridization	X	X	X	?
5. Breeding structure	X	X	X	X
Studies[2]	1-3	4-18	19-20	11-12,20-24

[1] **Explanation of techniques:**

Karyology: Comparative analysis of the diploid number and morphology of chromosomes.
Allozymes: Comparative analysis of polymorphism at specific gene loci by protein electrophoresis.
mtDNA: Comparative analysis of divergence of gene sequences in rapidly evolving, maternally inherited mitochondrial DNA.
VNTR: Comparative analysis of variable number of tandem repeat DNA (DNA fingerprinting).

[2] **Examples of genetic studies of felids:**

1. Phylogenetic distinction: 1. Wurster-Hill and Gary 1975; 2. Wurster-Hill and Centerwall 1982; 3. Wurster-Hill *et al.* 1987; 4. Collier and O'Brien 1985; 5. Wayne *et al.* 1989; 6. O'Brien this volume; 7. O'Brien *et al.* 1987c; 21. Olmsted *et al.* 1992; 22. Janczewski *et al.* 1992.
2. Phylogeographic history: 7, 8. Yukhi and O'Brien 1990; 9. O'Brien *et al.* 1987a; 10. O'Brien *et al.* 1987b; 11. O'Brien *et al.* 1990 and Roelke *et al.* 1993; 12. Packer *et al.* 1991b; 19. Miththapala 1992; 20. Menotti-Raymond and O'Brien 1993.
3. Genetic variation: 7-12, 13. Newman *et al.* 1985; 14. O'Brien *et al.* 1985; 15. Goebel and Whitmore 1987; 16. Miththapala *et al.* 1991; 17. Randi and Ragni 1991; 18. Hubbard *et al.* 1992; 19-20, 23. Gilbert *et al.* 1991.
4. Hybridization: 17-18.
5. Breeding structure: 12, 20, 23, 24. Packer *et al.* 1991a.

initial sample. Even small bits of bone, skin, or hair from museum specimens can be used. These techniques, for example, were used to analyze cellular DNA from the extinct saber-toothed cat *Smilodon fatalis* (of Rancho La Brea tar pit fame), which the results suggest was a primitive relative of the modern pantherines within the most recent felid radiation (Janczewski *et al.* 1992).

Table 3 indicates the techniques that are appropriate to the five areas of research outlined above, and reviews their application to studies of felid genetics. Wayne *et al.* (1992) provide a concise description of each technique and its relevance to conservation biology.

The role of molecular research in understanding evolutionary relationships at the species level is discussed by S. O'Brien under Taxonomy at the beginning of this book. Hybridization between domestic cats and wildcats is discussed in the Species Accounts, and the question of subspecies was examined previously in this chapter. Molecular analysis has been used at a resolution finer than the subspecies level by Packer *et al.* (1991b) to examine the relationship between two closely situated lion populations. Allozyme and DNA fingerprinting analysis was used to show that the small population of lions living within Tanzania's Ngorongoro Crater was probably founded by immigrants from the adjacent Serengeti National Park. The remainder of this discussion centers on the importance of studies of genetic diversity and breeding structure to felid conservation.

Genetic variation is thought to be essential to the long-term adaptability and persistence of populations by providing different options on which natural selection can operate in response to environmental change. Although the evolutionary significance of genetic diversity and the need for its conservation is widely recognized and accepted, actual demonstrations correlating genetic diversity and fitness have been few. Most studies have been laboratory experiments which examine only one index of fitness (e.g., growth rate) (Beardmore 1983, Allendorf and Leary 1986).

Loss of genetic diversity within a population occurs when it shrinks to a small size. This increases the chances for expression of harmful genes. Expression of deleterious mutations is synonymous with inbreeding depression, which also refers to the consequences of matings between closely related individuals. The physiological impairments resulting from inbreeding depression have been best documented by breeders managing small captive populations, especially domestic animals (Ralls and Ballou 1983). However, while the potential of inbreeding to drive isolated populations to extinction has been demonstrated in theoretical models (Senner 1980, Gilpin and Soulé 1986), in practice the costs of inbreeding, even in captive populations, have been difficult to predict (Ralls *et al.* 1988). In other words, the exact consequences of loss of genetic diversity are probably situation-specific, and will vary between both species and populations.

New evidence in support of the need to conserve large populations in order to maintain genetic diversity may well arise from future application of DNA fingerprinting to the breeding structure of felid populations, as was done for Serengeti and Ngorongoro Crater lions (Gilbert *et al.* 1991, Packer *et al.* 1991a). Results showed that reproductive success is highly skewed in coalitions of male lions: only two males per coalition in the Serengeti fathered almost all of the offspring in their pride, regardless of the size of the coalition (up to nine males). Not all potential breeders have an equal chance of passing on their genes, and thus lion populations are not panmictic (randomly mixed), as is often assumed in simulations which model population viability. Non-random breeding success leads to more rapid decay of genetic variation than predicted by simulation models (Lacy 1993). So far this study has been the only one to employ DNA fingerprinting to clarify the social organization and reproductive patterns of a population of wild felids, although captive populations have been analyzed (e.g., Menotti-Raymond and O'Brien 1993).

It appears to be a typical pattern of felid dispersal that female offspring establish home ranges close to their mother's range. Based not on genetic analysis but on known relationships, Smith *et al.* (1987b) found that the average degree of relatedness between neighboring female tigers in Nepal's Chitwan NP was 0.35, similar to a typical value for a lion pride, which almost always consists of closely related females (Sunquist and Sunquist 1989). The general pattern of felid social organization is that a male's home range overlaps those of several females and, if males do indeed actually mate with all females within their ranges (molecular analysis is necessary to confirm this), the potential for inbreeding and more rapid loss of genetic diversity arises. This is particularly the case if dominant males prevent others from breeding and sire a disproportionate number of offspring, as has been found for tiger (Smith and McDougal 1991) and lion (Packer *et al.* 1991a) populations. If the population is so isolated as to bar emigration of related and immigration of unrelated individuals, there is real cause for worry about population viability (see below). Smith *et al.* (1987a) suggest that this is a serious problem for tigers on the Indian subcontinent, where the structure of the meta-population is characterized by populations that are either completely isolated, or have a probability of genetic exchange considerably less than one individual per generation.

Population Viability Analysis

A minimum viable population (MVP) is one that meets "the minimum conditions for the long-term persistence and adaptation of a species or population in a given place" (Soulé 1987a: 1). It is theoretically sufficiently large to protect against extinctions caused by harmful and unpredictable genetic, demographic, or environmental factors over a given period of time (generally expressed in hundreds of years). Determination of a generic, rule-of-thumb MVP size has been the subject of considerable effort and debate (reviewed by Shaffer 1990) and, based solely on long-term conservation of genetic diversity, should be considered equivalent to an effective population size (Ne) of several hundred (Soulé and Simberloff 1986, Lande and Barrowclough 1987).

The concept of effective population size summarizes the genetic influences acting on a particular population, and has important implications for evolutionary processes (Wright 1969). Ne is defined as the size of an ideal population which maintains the same genetic diversity as the real population (Kimura and Crow 1963), and is equivalent to the number of breeding animals per generation. It is a function of social organization and population demographics, and as a standardized measure permits comparison between species, between populations of the same

Table 4
Ratios of Effective Population Size to Actual Population Size (Ne/N) Calculated for Cat Populations

Species and Population	Ne/N ratio	Reference
Ocelot, central Venezuela	0.37	Ludlow and Sunquist (1987)
Tiger, Chitwan National Park, Nepal[1]	0.40	Smith and McDougal (1991)
Florida panther, U.S.[2]	0.25-0.5	Seal *et al.* 1989
Puma, southwestern Alberta, Canada[3]	0.64	Dueck (1990)

[1] Included good field data on a key component of effective population size, variance in individual lifetime reproduction, gathered over 17 years of field work.

[2] Upper estimate (0.5) based on proportion of adults known to have bred over 7 years of fieldwork. These adults were treated as a single generation because not all animals were followed for entire period, and therefore data is lacking on individual production of offspring. Lower estimate is speculative.

[3] Dueck (1990) applied the formula developed by Reed *et al.* (1986) to field data collected by Pall *et al.* (1988). In their assessment of estimators' effective population size, Harris and Allendorf (1989) found that the formulae of Reed *et al.* (1986) tended to overestimate Ne/N by roughly 60%.

Part of the reason that there have not been more attempts to estimate Ne for cat populations is that reasonably accurate demographic data are needed, of the type that can be collected only through long-term study, and then with difficulty. Harris and Allendorf (1989) suggest the use of population simulation models—based on an initial short-term series of field data as well as the willingness of biologists "to make educated, insightful guesses" for key parameters related to social structure—to project population dynamics over individuals' lifetimes. For management purposes, they point out that it is probably not neccessary to strive for great precision in Ne estimates, given that unpredictable variation in demographic or environmental events can easily alter the rate of genetic loss.

species, and between the same population at different times. It is usually only a fraction of actual population size (N), because not all animals in the population are breeders. The smaller the ratio of Ne to N, the greater the chance for genetic drift and the greater the level of inbreeding characterizing a species (Chepko-Sade *et al.* 1987). Ne/N ratios appear to have been calculated for just three cat populations (Table 4). They imply that a minimum viable population of several hundred breeding animals would actually require nearly 1,000 animals.

Moreover, a population size sufficient to mitigate environmental and catastrophic uncertainty (habitat change, or an epidemic or natural disaster) should be considerably larger than one required only to conserve genetic diversity (Shaffer 1987, Lande 1988). Taking these factors into account, viable populations are thus expected to be of the order of several thousand individuals (Belovsky 1987, Soulé 1987b, C. Thomas 1990).

It is clear that such a goal is not obtainable for populations of the bigger cats in protected areas. Most of the world's protected areas are simply not large enough (see review in Chapter 1). However, MVP size decreases sharply if the population is not completely isolated, but maintains even a low rate of genetic migration from other populations. Simulation models indicate that immigration of new animals can substantially reduce a population's extinction risk (Soulé 1987c, Beier 1993). Many mammals have been shown to have low levels of genetic variation relative to other taxa (Selander and Johnson 1973, Powell 1974, Nevo 1978). Lande (1979) and Chepko-Sade *et al.* (1987) suggest that low levels of genetic variation and chromosomal evolution patterns indicate that the general trend of mammalian population organization is in small, semi-isolated and relatively inbred demes (sub-populations), occasionally augmented by immigration from neighboring demes. For these reasons, and because pumas in fragmented habitat in the U.S. have actually moved through narrow, natural landscape features within developed areas to reach larger habitat patches (Maehr 1990, Beier 1993), the need for movement corridors to connect small isolated reserves containing big cat populations has been emphasized in Chapter 1.

However, considerable controversy surrounds the real significance and utility of the MVP concept, much of it in the form of unpublished grumbling about whether such "ivory tower" thinking dictates that too-small populations be essentially written off. There has been a great deal of theoretical writing about conservation of MVPs, but few attempts at application as a management practice (Shafer 1990, Caughley 1994). The correlation between genetic diversity and fitness is theoretically robust but empirically weak (e.g., Beardman 1983, Allendorf and Leary 1986: 72-76), and would certainly benefit from further field work. However, signs of inbreeding depression can be very difficult to detect in the field unless the situation is very advanced (Smith and McDougal 1991).

With regard to cats, there are three well-researched examples which go furthest toward demonstrating small population vulnerability in the wild, rather than just on paper. The first, the Florida panther, is a very small population exhibiting relatively clear-cut symptoms of inbreeding depression. The total population now numbers about 30-50 adults in fragmented habitat (Logan *et al.* 1993), and incestuous pairings have been observed (Roelke *et al.* 1993). Genetic diversity within the population is very low (O'Brien *et al.* 1990, Roelke *et al.* 1993). Males have high levels of abnormal sperm and have over the last 20 years suffered an increasingly and unusually high incidence of cryptorchidism (one or both testicles undescended, with progressive loss of spermatogenesis). A recent increase in cardiac abnormalities, in some cases fatal, has also been observed (Roelke *et al.* 1993). An analysis of the population's viability concluded that the probability of extinction within 20 years is high unless there is management intervention (Seal *et al.* 1989).

The second example illustrates the vulnerability of small populations to unpredictable environmental events. The population of lions in Tanzania's Ngorongoro Crater over 1957-1961 was estimated to number 65-70 individuals, including young. In 1961-1962, there was an infestation of biting fly (*Stomoxys calcitrans*) in the Crater, following exceptionally heavy rains. Lions appeared to be the preferred hosts for the flies; repeated bites led to skin infections and eventually emaciation. Unable to hunt effectively, the population crashed to nine adult females and one male by June 1962. Although the population rebounded to its present level of between 75-125 animals, all members are descended from only 15 founders, and show a significant lack of genetic diversity and high levels of abnormal sperm relative to lions from the nearby Serengeti, the source of the founders. There are indications of declining reproductive success. The Crater is an ecological island which contains only a subset of the large mammals found in the Serengeti. Wild dogs occurred in the 1960s, but have since disappeared. Male lions have occasionally immigrated into the Crater, but none have successfully bred since 1969 (Packer *et al.* 1991b).

The third example shows why these populations should not be written off. As discussed in the species account, wild cheetahs from both east and southern Africa are virtually identical in nuclear coding DNA, on a par with deliberately inbred strains of laboratory mice (O'Brien *et al.* 1985). The cheetah population appears to have passed through a severe population bottleneck around the time of the late Pleistocene extinctions of large mammals (Menotti-Raymond and O'Brien 1993).

Yet the consequences for the cheetah today are not clear. Since the time of the bottleneck, there has been ample time for natural selection to eliminate the most deleterious genes arising from inbreeding depression (i.e., those individuals with severe defects would not have survived). However, while moderate levels of variation have accumulated in non-coding genetic material, it would theoretically take "millions of years" to restore similar levels of coding DNA heterozygosity for a species as depauperate in variation as the cheetah (Menotti-Raymond and O'Brien 1993). Problems symptomatic of inbreeding depression have been found in the global captive population, such as low levels of conception and elevated cub mortality (Marker and O'Brien 1989), but the outstanding reproductive successes achieved by some institutions indicate that inappropriate management is at least partly responsible (Lindburg *et al.* 1993, Marker-Kraus and Grisham 1993, Wildt *et al.* 1993). Similar evidence of poor reproduction has not been found in the intensively studied wild population in the Serengeti (Laurenson *et al.* 1992), despite Serengeti males having high levels of abnormal sperm (Wildt *et al.* 1987a). Cub losses in the Serengeti, which are very high (95%), are attributable to environmental factors, including lion aggression; moreover, females will rapidly conceive again following loss of a litter. In reserves, cheetah numbers appear to be affected far more by interspecific competition with other large predators than by side-effects of genetic homozygosity (Caro and Laurenson 1994).

Because of their ecology, the big cats are highly vulnerable to isolation in small vulnerable populations. The standard practice of setting aside a scattered network of reserves may not prove to be very effective for these species. The theoretical tools for analyzing population viability are available, as is the requisite field-collected biological data (on at least a crude level) for most big cats. Better use should be made of tools such as GIS habitat maps and population simulation models to demarcate subpopulations of these species, especially those of Categories 1-3, and a first-order evaluation of their status should be done. Population viability analysis for cats has so far been done for only three taxa—the Florida panther (Seal *et al.* 1989), the Sumatran tiger (Tilson 1992a), and the Asiatic lion (Walker 1994). These efforts have been led by the

Conservation Breeding Specialist Group (CBSG), which has done similar conservation analyses for a wide range of non-felid species. The tools of conservation biology need to be applied more systematically to wild cat populations, with more active involvement of field specialists.

Future research should not only go toward identifying which cat populations are viable and which are not. Population viability analysis does not necessarily identify the specific threats facing a population, nor lead automatically to management solutions. As emphasized by Caughley (1994): if a population is declining or small, it is more effective in the long-term to provide a cure (find ways to increase population size) rather than merely treat the symptoms (manipulate the population genetically). The limiting factors, or agents of decline, should be identified through an experimentally-designed study, and appropriate management actions taken. It will not always be possible to increase population size—for example, if the limiting factor is the size of a reserve isolated in a hostile environment—but it is important that research projects are designed to address and, if possible, manipulate and alleviate the factors which led to the population vulnerability in the first place.

Infection and Disease

There is increasing appreciation of the effects that infection and disease can have on wild populations (May 1988). Infection refers to the presence of parasites (from bacteria and viruses to arthropods) within a host; disease results only if infection is clinically harmful. Infection and disease can potentially impact survival, reproduction, dispersal, and distribution of host populations (Scott 1988), as well as their level of genetic diversity (O'Brien and Evermann 1988).

The actual effects of disease upon wild cat populations are little-known. There is little documentation of the incidence of disease, let alone the impact, and a review of the literature produced few examples of infection or disease leading to a major decline in a population of wild cats (Table 5).

The most important and dramatic disease outbreak occurred at the time of writing, so that it is not yet possible to draw conclusions about its impact. By July 1994, an epidemic of canine distemper virus (CDV) had affected 20%-30% of the 3,000 lions in Tanzania's Serengeti National Park, and about 87 lions in a monitored population of 250 died or disappeared. The first notable clinical signs were facial and foreleg spasms, loss of control of limbs, and seizures. More than half of all lions with clinical signs died or disappeared. Canine distemper has been considered rare in felids, only occasionally affecting individual cats in zoos, but blood samples from Serengeti lions in 1985 show that the population may have been exposed to CDV around 1980. Since 1992, however, there have been four epizootics of CDV affecting predominantly African and Asian cats in U.S. zoos. The extent of the morbidity and mortality in these recent outbreaks, coupled with the severity of the Serengeti outbreak, suggests that CDV has acquired increased pathenogicity for cats. Controlling the Serengeti epidemic through vaccination of the lions was not possible, as existing modified live CDV vaccines were designed for domestic dogs and could cause the disease when given to other carnivores.

The Tanzanian authorities launched a program in the Serengeti area to vaccinate domestic dogs (the most likely vector of the disease, since an outbreak of CDV occurred in the adjoining Masai Mara reserve in 1991). However, as shown by the 1980 outbreak of CDV in the Serengeti, the disease can run its course, reducing but not threatening healthy populations overall, while vaccinating about 30,000 domestic dogs in the vicinity is a major challenge, particularly since their average life span is 30 months and the program would have to be continued for many years to reduce the risk of new epidemics.

The rapid action of the Tanzanian authorities in carrying out an extensive veterinary investigation into the Serengeti epidemic has provided important insights which form the basis for continued monitoring of susceptible carnivore populations (L. Munson, C. Packer and M. Roelke, pers. comm.).

On the other hand, cats sometimes take advantage of the effects of disease upon prey populations. For example, wildcats in Scotland concentrate their predation on wild rabbits afflicted with myxomatosis (Corbett 1979).

Although a wide variety of diseases has been documented for cats in captivity (e.g. Wallach and Boever 1983, Fowler 1986, Seidel and Wisser 1987, Pedersen 1988, Bush *et al.* 1992), opportunities for interspecific transmission and host susceptibility are probably increased in these conditions. For example, although Rasheed and Gardner (1981) isolated feline leukemia virus (FeLV) from a captive leopard cat, it has not been reported from any wild felid population except European wildcats, which are closely related to and interbreed with domestic cats, which are frequently infected with FeLV. However, it is still not clear whether FeLV is transmitted from domestic cats to wild cats, or rather the virus is sustained within wildcat populations (McOrist *et al.* 1991).

Table 5 presents a preliminary list of viral and bacterial pathogens reported in wild cats. In some cases, the pathogen is detected by sera reactivity to an antigen in the laboratory, rather than by clinical symptoms observed either in the field or by examination or necropsy. In all cases, however, the etiology and effect of the viruses on their host populations are unknown.

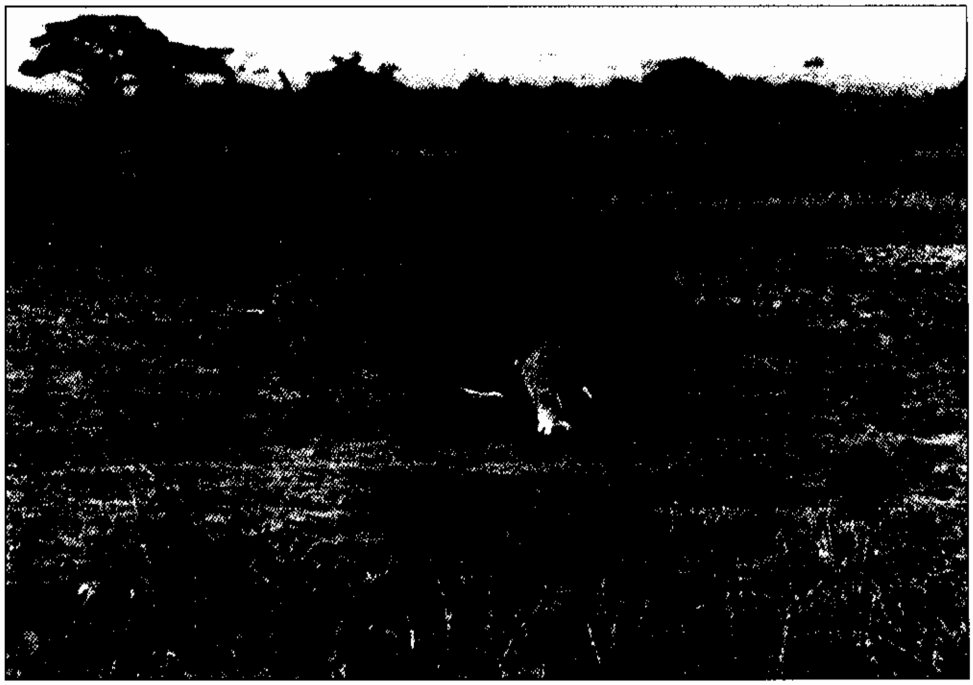
This lack of knowledge stems from practical difficulties

Table 5
Exposure to Infectious Micro-pathogens Documented in Wild Cat Populations

Pathogen	Species	Area	Ref.
Anthrax[a]	Cheetah	Namibia[c]	15
Bubonic plague	Bobcat	New Mexico	8
Canine distempter virus (CDV)[a, b]	Lion	Serengeti[c]	20
Feline calicivirus (FCV)[a]	Puma	Florida	12
	Wildcat	France	13
Feline coronavirus (FCoV)[a]	Cheetah	Serengeti	10,17
	Puma	Florida	12
	Wildcat	France	13
Feline cytauxzoonosis	Bobcat	North America	7
	Puma	Florida	12
Feline immunodefiency- type (FIV) viruses	Lion	Kruger, Serengeti	1,2
	Cheetah	Serengeti	1
	Puma	North America	1
	Bobcat	Florida	1
	Leopard	Kruger NP, So. Africa	19
Feline leukemia virus (FeLV)[a]	Wildcat	Scotland[c]	3
	Wildcat	France	13
Feline panleucopenia virus (FPV)[a]	Canada lynx	North America	4
	Bobcat	California	9
	Puma	North America	11
	Puma	Florida	12
Feline rhinotracheitis (FHV)[a]	Bobcat	Florida	12
	Wildcat	Scotland	3
	Wildcat	France	13
Feline syncytia-forming virus	Puma	Florida	12
Rabies[a,b]	Canada lynx	North America	4
	Bobcat	Virginia	5
	Eurasian lynx	Slovakia	16
	Tiger	India	6
	Puma	North America	14
	Puma	Florida[c]	12
	Leopard	Caucasus Mtn. region	18
	Snow leopard	Kazakhstan	18

[a] Pathogen potentially fatal
[b] Generally considered uncommon in felids
[c] Cat death ascribed to this pathogen

1. Olmsted *et al.* 1992; 2. Spencer *et al.* in press; 3. McOrist *et al.* 1991; 4. McCord and Cardoza 1982; 5. Carey and McLean 1978; 6. Burton 1950; 7. Kier *et al.* 1982; 8. Poland *et al.* 1973; 9. Lembeck 1978; 10. Heeney *et al.* 1990; 11. Hansen 1992; 12. Roelke *et al.* 1993; 13. Artois and Remond 1994; 14. Storer 1923; 15. Lindeque *et al.* in prep.; 16. Hell 1992; 17. Evermann *et al.* 1993; 18. Heptner and Sludskii 1972; 19. Brown *et al.* 1993; 20. Anon. 1994e.



Lion stricken by seizure caused by canine distempter virus in the Serengeti, Tanzania, February 1993.

in the field, both in identifying sick animals and finding dead ones, and then attributing with certainty the death to disease. Most wild animals are host to some form of parasite or another, and parasite loads can increase when the animal is in poor condition due to other factors, resulting in a vector between infection and loss of fitness.

A program to monitor infection in wild populations is most useful if carried out concurrently with a field study. Thus, the movements, reproductive activity, and ultimate fate of the study animals can be evaluated in the light of knowledge of the presence or absence of infection. While clinico-pathological investigation remains the best way to identify infection and monitor the role it plays within a particular population, it is also useful to collect blood samples from study animals immobilized for marking or radio-collaring (see Appendix 2). Sera extracted from the samples can be frozen and later tested for reactivity to various antigens, and can be used as well for molecular analysis. Skin and fecal samples can also be collected for examination for macro-parasites.

M. Artois (*in litt.* 1993) suggests three reasons why monitoring disease in wild populations is important and deserves more emphasis from field biologists:

1. Disease can have a devastating impact on small populations, as described for the lions of the Ngorongoro Crater (Packer 1991b), or as in the well-known case of the black-footed ferret (Thorne and Williams 1988). A proper disease monitoring program for small populations allows the best chance for successful intervention.

2. Even for larger populations, disease can be a major environmental influence. Infectious disease can affect populations in a manner independent of host density such that sparse and widely dispersed populations are nonetheless at risk.

3. Biological samples are important for building up clinical and ecological knowledge of the circulation of pathogens.

Summary and Conclusions

This review of research effort for cats suggests that the following topics are of conservation priority. Areas for future research are summarized generally below, with links to specific priority projects in Part III.

1. Natural history studies of cats ranked in Categories 1-3 are urgently needed (see priority projects in Part III). Without basic information on behavior and ecology, attempts to conserve these species are bound to be somewhat inappropriate and inefficient. These studies should be carried out both within protected areas, to provide baseline data, and in modified habitat typical of

the predominant regional form of land use, to assess implications for species conservation.

2. Most of these species occur in tropical Asia and Latin America. In addition, the cats of north Africa and southwest Asia have scarcely been studied. Natural history studies should be carried out with the active participation of local residents and experts, including hunters. The value of these studies would be increased if several cat species were studied simultaneously by a small team.

3. Small, isolated populations are highly vulnerable to extinction. This has been well documented for cats, particularly the large species, yet there has been little systematic effort to map out cat population fragmentation and distribution beyond the more obvious examples of occurrence in protected areas. A number of priority projects have been put forward in Part III to conduct presence/absence surveys to map discrete populations of cat species. Particular attention should be paid to identification of potential and actual habitat corridors to permit migration between otherwise isolated populations.

4. Standardized, replicable techniques to census cat populations still need to be worked out, especially for the tiger in India (Project 48). Otherwise, there is little hope of accurately assessing the effectiveness of population conservation efforts. Density estimation methods (spoor surveys, photo traps) should be tested against populations whose size is known from long-term study (Project 7).

5. Long-term studies are necessary to understand "typical" felid population dynamics and the role played by cats in ecosystems (see Projects 16, 17, 24, 30, 45, 101, and 103). They are most suited to protected areas where the population dynamics of other non-felid species, especially prey, are also studied. In the future, long-term studies should be mounted in protected areas which hold large populations of cats of conservation concern, on either a regional or global level. It is also important to study the predator-prey dynamics of cat populations located outside protected areas. Such studies could most appropriately be undertaken by having a field researcher work under a long-term development project with a conservation component.

6. Research projects designed both to develop and implement solutions to conflict between big cats and people are of high priority (see Chapter 2, and Projects 5, 6, 22, 23, 31, 32, 51, 52, 71, 74, 93, and 102). Studies should be carried out in areas typical of the predominant regional form of land use, or should alternatively focus on potentially viable, unprotected populations.

7. There have been relatively few attempts to specifically apply the lessons of theoretical conservation biology to the field. A cooperative effort should be made to define Minimum Viable Population size for cat species, based specifically on insight gained through long-term studies of behavior and ecology (see Project 8). This exercise would greatly aid reviews of species status, and prioritization of conservation effort. The following species should be looked at first: Iberian lynx, tiger, snow leopard, cheetah, lion, jaguar, puma, leopard.

8. Field studies of cat populations could benefit from closer cooperation with the laboratory sciences. Field researchers should take biological samples from cat species at every opportunity to help advance knowledge of felid taxonomy, genetics, and disease (see Project 9).

Part II
Major Issues in Cat Conservation

Chapter 4
Trade

Introduction

Historically, cats have been most prized for their fur. The glamour of cat fur can probably be traced back to the first people brave enough to slay a fearsome large predator. In many cultures around the world, cat pelts are still worn by the elite as symbolic expressions of status and power. These overtones, coupled with the physical beauty of cat fur, also explain their appeal to the fashion-conscious modern woman. An advertisement typical of the 1960s and 1970s enticed buyers with the following: "Untamed...the Snow Leopard, provocatively dangerous. A mankiller. Born free in the wild whiteness of the high Himalayas only to be snared as part of the captivating new fur collection...styled and shaped in a one-of-a-kindness to bring out the animal instinct in you" (Conway 1968).

The appearance of large numbers of pelts of tigers, leopards, jaguars, snow leopards, and their kin in boutiques from Montevideo to New York and Berlin led to alarm that trade might drive these species to extinction. This was one of the primary concerns which fueled the development of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES—see Box 1), which entered into force in 1975. As implementation of the Convention by its signatory states (particularly the importers) has improved, those species of spotted cat traded in large numbers, both before CITES entered into force and in its early days, have now almost completely disappeared from the fur trade. The volume of cat skins legally traded in 1990 is only about a quarter of the volume of trade in 1980 (WCMC unpubl. data). Latin America and sub-Saharan Africa have been replaced as the main suppliers by four northern countries—the United States, Canada, China, and Russia. The modern fur trade in cats relies almost entirely on three lynxes and the Chinese leopard cat.

Cats are one of the wildlife families used by the fur trade which are entirely wild-caught, rather than farmed. Their pelts are also high-value compared to most other species in the trade, even when demand is relatively low. For example, in the 1989-1990 season the average price paid to the trapper for a Canada lynx pelt was CA $117 (U.S. $85), which is high compared to the average value for other fur-bearers—U.S. $67 for fisher, $57 for marten, $17 for beaver, and $9 for fox. In 1984-1985, lynx pelts were much more valuable—at approximately U.S. $445, worth 18 times as much as a fox pelt (Canadian Wildlife Service *in litt.* 1994). In other words, relatively low harvests can generate significant revenue. Theoretically, fur trade has the potential to be an important component of a sustainable use strategy for cat conservation, providing an economic incentive to maintain wild lands. The management of commercial trapping of the two North American lynxes is reviewed to examine whether such an approach actually works.

Illegal trade, on the other hand, has the potential to be among the fastest and most destructive threats to wild cats when it leads to commercial poaching (as opposed to illegal hunting for other reasons, such as livestock protection). The fur trade from Latin America in the late 1970s to early 1980s is a good example. The region was the major supplier to the world market, but most exports were in contravention of national hunting and export bans. Imports up to the mid-1980s were legal, however, so that import statistics indicate how large the illegal trade was. When trade is clandestine and "underground," however, it can be very difficult to gauge its true volume, identify consumer motivation and appropriate corrective measures, and enforce prohibitions effectively. When the product is high-value, as most cat products are, the resulting environment is conducive to official corruption, which further compounds efforts to bring the problem under control. The dynamic depends very much on the product and its market. Illegal trade in cats and their products is reviewed, and the conclusion reached that it is at its worst with regard to the big Asian cats, particularly the tiger.

This chapter reviews the history of the international trade in cat furs and other products up to the present time. Trade in cat products cannot be evaluated separately from hunting, and the biological impact of commercial hunting

Box 1
The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

CITES is a treaty which restricts and regulates trade in wildlife. Its preamble recognizes that "international cooperation is essential for the protection of certain species of wild fauna and flora against overexploitation through international trade." It entered into force on July 1, 1975, with a total of 10 nations as ratified signatories. As of May 1994, its Parties (signatory nations) number 122. CITES functions on the basis of its four appendices, establishing different trade restrictions for species listed on Appendices I, II, and III and allowing for trade only when a competent government authority has issued a permit conforming to the permit form in Appendix IV (Bräutigam 1989). Species are listed on Appendices I or II by majority vote of the Parties.

Appendix I: includes "all species threatened with extinction which are or may be affected by trade. Trade in specimens of these species must be subject to particularly strict regulation in order not to endanger further their survival and must only be authorized in exceptional circumstances."

Appendix II: includes "(a) all species which although not necessarily now threatened with extinction may become so unless trade in specimens of such species is subject to strict regulation in order to avoid utilization incompatible with their survival; and (b) other species which must be subject to regulation in order that trade in specimens of certain species referred to in the above sub-paragraph may be brought under effective control" (i.e., so-called "look-alike" species which are difficult to distinguish from others listed on Appendix I. Several felid species have been listed on Appendix II for this reason).

Appendix III: includes "all species which any Party identifies as being subject to regulation within its jurisdiction for the purpose of preventing or restricting exploitation, and as needing the cooperation of other parties in the control of trade." Any Party may unilaterally list a native species on Appendix III.

In general, trade in Appendix I species is prohibited except under certain essentially non-commercial circumstances (zoological exchange, scientific study, movement of personal effects or legitimately taken hunting trophies, etc.—with the exception of certified captive-bred specimens, which can be traded commercially). Both import and export certificates are required before an international transaction can take place. Trade in Appendix II species is supposed to be permitted only when the exporting country's Scientific Authority (typically the government agency responsible for wildlife management) has determined trade to be "not detrimental to the survival of the species". Trade in both Appendix II and III species require export permits only. The three Appendices are amended at bi-annual conventions by majority vote of the Parties, ostensibly in response to changes in the conservation status of a species or subspecific populations (although sometimes politics overwhelms biological considerations). All felid species are listed on either Appendices I or II; the listing as of March 1995 appears below. New listing criteria were approved at the Conference of the Parties in November 1994 because the previous criteria were not considered sufficiently objective or biologically based. Some cat species listed on Appendix I cannot seriously be considered to be endangered by trade.

In theory, the treaty permits an unprecedented degree of control over international commercial trade in wildlife, and should have far-reaching effects toward assuring the viability of threatened species populations around the world. Moreover, a comprehensive global trade oversight mechanism is established through a requirement that signatories submit annual reports detailing all transactions which require CITES permits (import, export ,and re-export). Data from these reports are managed by the World Conservation Monitoring Centre (WCMC) in the U.K. under contract to the CITES Secretariat in Switzerland. In practice, however, a number of difficulties impede both the functioning of the treaty and the compilation of accurate trade data, the following of which are most pertinent to the commercial trade in cats and their products (Johnson 1989).

1. Not all countries are Party to CITES. Trade between these countries is not reported to CITES, and some ostensibly illegal shipments may be "laundered" through these countries.

2. The effectiveness of the implementation of CITES varies from country to country. Some have not

Continued on next page

enacted domestic legislation to implement or conform to the treaty, in part or in entirety. Even one of the most scrupulous examples of implementing legislation, the Endangered Species Act of the United States, has its share of loopholes and red tape (Kosloff and Trexler 1987, O'Brien and Mayr 1991). Problems with forged CITES documents occur frequently. The accuracy, frequency, and format of "annual" reports (some Parties have never submitted even one) are highly variable.

3. The scope of CITES is necessarily limited in that it deals only with international, not domestic, trade in listed species. The Convention has no direct impact on a country's domestic wildlife conservation policies.

4. Different Customs agencies use different units of measure (e.g., kg of skins vs. numbers of pelts or skin plates), which hinders clarity when WCMC compiles reported trade data. Customs agencies may treat country of origin differently (e.g., skins exported from Paraguay through France to a third destination country might be reported as originating in either Paraguay or France, depending on the non-standardized criteria used by the destination country).

5. Illegal trade is obviously not reported through CITES.

During the early years of the Convention, these problems were acute. Shipments of cat furs which showed up in the annual reports of importing countries were not listed in those of exporting countries, and vice versa. For example, in 1978 West Germany reported the import of 10,171 oncilla pelts from Uruguay but, although Uruguay was the only Latin American country to submit a report for that year, the shipment of oncilla pelts was not recorded (Boydell 1980). Meanwhile, in West Germany's 1979 CITES report, no imports were listed from Brazil, which had banned all export of wildlife and wildlife products, but official German Customs statistics reported the import of 61,400 cat skins from that country (Broad 1987). After 1980, correlation between Germany's import figures and others' export figures improved—and showed that skins continued to be imported in large numbers from Paraguay, which had ostensibly banned the export of spotted cats in 1981 (Caldwell 1984, Broad 1987). The effectiveness of the Convention depends heavily upon the Parties' observance of national legislation, which can be stricter than the CITES Appendices. WWF-U.S. is publishing a series of guides to national wildlife trade legislation (Fuller *et al.* 1987, Nichols *et al.* 1991) which will serve a very useful purpose.

Despite its weaknesses, CITES is an indispensable tool for controlling international trade in wildlife. While it only works as well as individual Parties, at the very least it provides the best information available on global trade patterns for all species of cats and helps to fix an order of magnitude on market sizes and organization.

Cat Species Listings on the CITES Appendices, March 1994

Appendix I

Cheetah, *A. jubatus*[1]
Caracal, *C. caracal*[2]
Asiatic golden cat, *C. temmincki*
Black-footed cat, *F. nigripes*
Jaguarundi, *H. yaguarondi*[3]
Ocelot, *L. pardalis*
Oncilla, *L. tigrinus*
Margay, *L. wiedi*
Iberian lynx, *L. pardinus*
Geoffroy's cat, *O. geoffroyi*
Andean mountain cat, *O. jacobitus*
Leopard cat, *P. b. bengalensis*[4]
Flat-headed cat, *P. planiceps*
Rusty-spotted cat, *P. rubiginosus*[5]

Appendix II

Caracal, *C. caracal*
Bornean bay cat, *C. badia*
Chinese mountain cat, *F. bieti*
Jungle cat, *F. chaus*
Sand cat, *F. margarita*
Wildcat, *F. silvestris*
Jaguarundi, *H. yaguarondi*
Serval, *L. serval*
Canada lynx, *L. canadensis*
Eurasian lynx, *L. lynx*
Bobcat, *L. rufus*
Pampas cat, *O. colocolo*
Kodkod, *O. guigna*
Manul, *O. manul*

Continued on next page

Appendix I	Appendix II
Puma, *P. concolor* subspecies[6]	Leopard cat, *P. bengalensis*
Clouded leopard, *N. nebulosa*	Rusty-spotted cat, *P. rubiginosus*
Asiatic lion, *P. leo persica*	Fishing cat, *P. viverrinus*
Jaguar, *P. onca*	African golden cat, *P. aurata*
Leopard, *P. pardus*[7]	Puma, *P. concolor*
Tiger, *P. tigris*	Lion, *P. leo*
Marbled cat, *P. marmorata*	
Snow leopard, *U. uncia*	

Notes

1 Annual export quotas for live specimens and hunting trophies are granted as follows: Botswana-5; Namibia-150; Zimbabwe-50.
2 Asian populations only.
3 Central and North American populations only.
4 Bangladesh, India, and Thailand populations.
5 Indian population only.
6 Three subspecies: *coryi* (Florida), *costaricensis* (Central America) and *cougar* (eastern North America).
7 Annual export quotas for hunting trophies are granted as follows: Botswana-100; Central African Republic-40; Ethiopia-500; Kenya-80; Malawi-50; Mozambique-60; Namibia-100; South Africa-75; Tanzania-250; Zambia-300; Zimbabwe-500.

on wild cat populations is discussed. The relationship of hunting and trade to cat conservation is examined by means of two case studies: the bobcat and lynx harvest programs in North America, and the illegal Asian trade in tiger bone.

International Trade in Cat Furs

Records from the early days of the fur trade are scarce, but for one year, 1763, there are records showing that 4,150 lynx pelts were exported from Canada to England, comprising a mere 2% of the furs in trade that year (Poland 1892). However, records of purchases of Canada lynx pelts by the Hudson's Bay Company during the 19th century attest to the growing popularity of cat pelts. Peak harvests were of the order of 80,000 pelts annually in the late 1800s, but they declined sharply after the turn of the century (Elton and Nicholson 1942). In the early 1900s, approximately 64,000 bobcat and lynx pelts were sold annually in the United States, the world's largest fur market for much of this century (Osborn and Anthony 1922). Following the Depression and World War II, the fur trade's source of supply underwent a major shift from mainly wild-trapped to mainly ranched animals (IFTF 1989). Cats, however, are not ranched, and their proportion within the wild-caught minority of furbearers increased dramatically during the 1960s.

The mushrooming popularity of spotted fur in North America is traced to an appearance made in 1962 by the American First Lady Jacqueline Kennedy wearing a leopard coat (Fig. 1), setting off a major trend (Nilsson *et al.* 1980). The IUCN issued a warning at its 1963 General Assembly that "the present fashion...of spotted cats is a threat to the continued existence of these kinds of animals," with particular reference to the leopard and the jaguar (Anon. 1971). Estimates of annual imports into the United States and Europe during the late 1960s indicate that the pelts of over 10,000 leopards, 15,000 jaguars, 3,000-5,000 cheetahs and 200,000 "ocelots" (in this case, a trade name covering similar species such as the margay and oncilla) reached the market annually (Gieteling 1972, Fitzgerald 1989). A top quality jaguar coat fetched U.S. $20,000 in the fur boutiques of New York, and Myers (1973) estimated that international trade in spotted cat skins was worth approximately U.S. $30 million at this time.

In September 1971, the International Fur Trade Federation (IFTF), in association with IUCN and WWF, concerned that the current level of trade might pose a threat to some cat populations, strongly recommend to its members a voluntary moratorium on trade in the skins of three large cats—tiger, snow leopard, and clouded leopard—and a three-year ban on the leopard and the cheetah. The IFTF also helped to fund investigations into the status of exploited cats in South America and Africa; both studies concluded that international fur trade had led to unsus-

Figure 1. Cat fur fashions in the 1960s displayed in *Animals* magazine. Source: Anon. (1971).

tainable hunting pressure in many areas (Koford 1976, Myers 1975, 1976). The IFTF's moratorium and ban were not universally respected (see Appendix 6 for a statement by the IFTF). Producer and consumer countries began to pass protective legislation for many of the larger cats and, when CITES entered into force in July 1975, all felids were listed on either Appendix I or II (see Box 1). With all the exploited big cats thus prohibited from international commerce via their placement on Appendix I, the industry focused on the smaller species.

The small spotted Latin American cats had been traded throughout the 1960s as well, and in greater volume than the larger cats, in part because it takes more of them to make a coat. "Ocelot" pelts comprised the vast majority, with 133,069 officially imported into the United States alone in 1969 (Myers 1973). As ocelot populations were hunted out and publicity increasingly focused on the need to protect this species, trade in pelts of other small spotted cats of South America—the margay, oncilla, and Geoffroy's cat—grew during the late 1970s to early 1980s. Trade volume in felid pelts was very high during this period, and was the subject of a special review in the 1978 annual report of the CITES Secretariat (Anon. 1978). The report notes: "The available customs figures for all countries in 1977 total approximately 570,000 imports and 615,000 exports. Although there is a good deal of overlap in these figures, the true totals are much higher because of the lack of Customs' data from most countries." Problems with documenting the extent of the trade in cat furs lent impetus to calls for governments to be regular in submission of annual trade reports, and to the creation of a centralized data base to monitor that trade.

Many South American countries had prohibited trade in their native cats before CITES became effective (e.g., Brazil in 1967, Venezuela in 1970, Chile in 1972, Colombia in 1973, Peru in 1975, Argentina in 1976: Broad 1987). However, traders from these countries smuggled skins out and laundered their exports to markets abroad through other outlets. Colombia's Amazonian free port of Leticia was notorious (Smith 1976). Leticia's status was revoked in 1973 after the documentation of widespread abuse of trade privileges (Inskipp and Wells 1979). It is apparent from the numbers exported that the bulk of furs exported from Paraguay and Bolivia during the period 1979-1985 must have been re-exports of pelts taken and smuggled in from neighboring countries, which were formerly major exporters with trade networks in place. In Europe, the free port of Hamburg facilitated the entry of shipments with CITES documents either of dubious validity or lacking altogether, as management authorities had no jurisdiction in these zones (Inskipp and Wells 1979). Customs in some countries also had no jurisdiction over transit trade.

Since then, the world trade in cat skins has shown a steadily declining trend, and is now largely legal. In 1980, CITES-reported world trade in cat pelts totalled some 450,000; by 1990, it had fallen to just over 100,000 (WCMC unpubl. data). The number of species in trade has declined by more than half, and trade in the remaining species is decreasing. A major cause of the decline was a strict import ban enacted by the European Community in October 1986 on Latin American spotted cat furs, and on leopard cat in 1988. For example, 82,500 cat skins legally exported from Argentina in early 1987 were refused entry into Europe (Broad 1987). Changes in fashion have been another major factor, brought about in no small part by the campaigns of pressure groups.

As exports from Latin America have fallen steeply in recent times, legal trade in cat furs now involves only countries of the northern hemisphere, and has depended on just four species: the bobcat, Canada and Eurasian lynxes, and the leopard cat from China (Fig. 2). As with the small neotropical spotted cats, these four species have been harvested in large numbers, and there is cause for concern that trapping pressure in the 1980s on at least two species, the Canada lynx and the leopard cat, has led to population declines (see Species Accounts for details).

Table 1 provides an overview of species in the skin trade. Numbers of pelts in trade (net trade) have been calculated from data in annual reports to CITES (McMahan

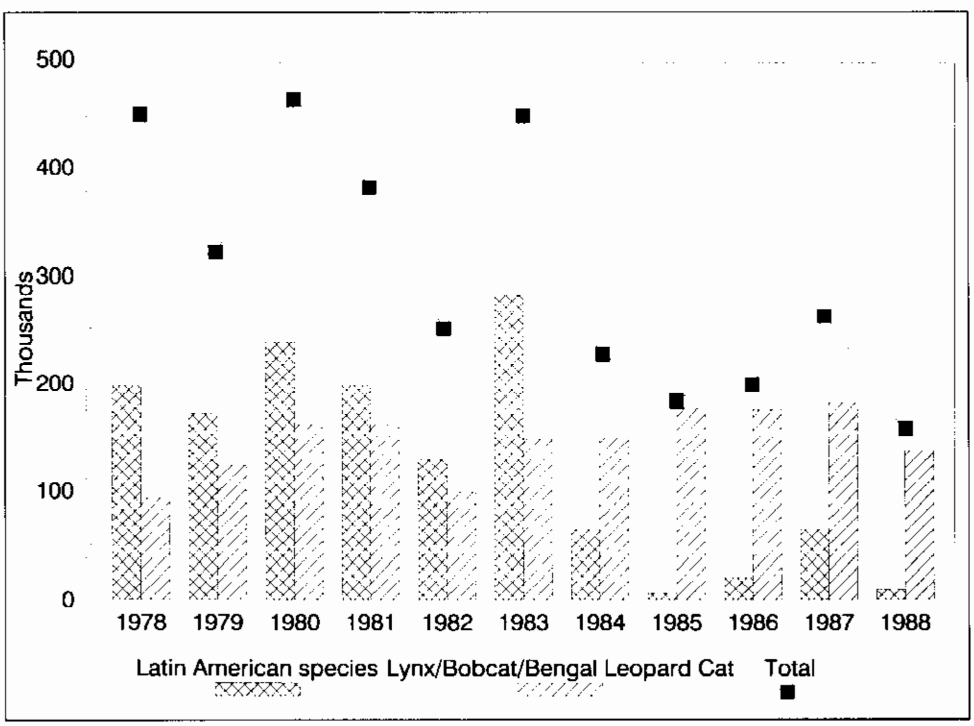


Figure 2. Trade in skins of Felidae, 1978-1988. Source: TRAFFIC International from CITES Annual Reports.

Table 1
CITES-reported International Trade in Cat Skins, 1976-1990

High volume commercial trade, current (total 108,000 - 1.3 million skins)

Species	Average Annual Trade	Trade in 1990	Major Exporters[1]	Trend
Leopard cat, *P. bengalensis*	85,985	86,911	CN	Declining
Bobcat, *L. rufus*	57,208	18,405	US, CA	Declining
Canada lynx, *L. canadensis*	19,034	7,386	CA, US	Cyclical
Eurasian lynx, *L. lynx*	7,227	3,366	CN, RU	Declining

High volume commercial trade, past (total 76,000 - 470,000 skins)

Species	Average Annual Trade	Peak Years	Trade in 1990
Geoffroy's cat, *O. geoffroyi*	31,107	1978-1984; 1987	1,521
Oncilla, *L. tigrinus*	23,584	1978-1984	0
Ocelot, *L. pardalis*	14,548	1976-1983	21
Margay, *L. wiedi*	8,548	1977-1983	2
Wildcat, *F. silvestris*	5,125	1977-1986	46

Low volume commercial trade, past (total 6,000 - 45,000 skins)

Species	Average Annual Trade	Peak Years	Trade in 1990
Jungle cat, *F. chaus*	2,909	1979-1983; 1988	0
Pampas cat, *O. colocolo*	1,955	1979-1981; 1987	0
Manul, *O. manul*	1,721	1978-1984; 1987	0
Caracal, *C. caracal*	684	1980	35
Serval, *L. serval*	392	Steady decline	6

Primarily non-commercial, especially trophies (total 200 - 10,000 skins)

Species	Average Annual Trade	Trade in 1990	Trend
Lion, *P. leo*	645	688	Slightly increasing
Leopard, *P. pardus*	566	657	Slightly increasing
Puma, *P. concolor*	294	70	Steady, low
Jaguar, *P. onca*	117	0	Low, declining
Cheetah, *A. jubatus*	102	8	Declining
Tiger, *P. tigris*	16	9	Steady, low

[1]CA = Canada; CN = China; RU = Russia; US = United States.

1986, Broad 1987, WCMC unpubl. data). Fifteen years of trade data have been averaged for each species to index the representation of each within the skin trade.

The bobcat and leopard cat have been part of the fur trade in greater numbers and for a longer period of time than the Latin American small spotted cats, even though the latter have more good quality habitat available to them (Amazon Basin). However, concern among the Parties to CITES regarding the biological impact of the fur trade has centered on the neotropical cats, to the extent that four species—the ocelot, oncilla, margay, and Geoffroy's cat—were upgraded from CITES Appendix II to Appendix I in 1989 and 1992, despite the fact that international trade in pelts had virtually ceased by the mid-1980s.

In 1985, the Parties actually downgraded the Chinese population of the leopard cat subspecies *P. bengalensis bengalensis,* which is believed to occur only in Yunnan province (J. Yu *in litt.* 1991), from Appendix I to Appendix II, even though no management programs were in place and no status surveys had been undertaken (two requirements upon which the Parties are usually insistent). Exports of leopard cat skins from China shot up shortly thereafter, from about 19,000 pelts in 1983 to 89,000 in 1984 and over 200,000 in 1987. Based on a survey of the inventory held by major fur trading companies in China, J. Yu (*in litt.* 1991) believed that this subspecies made up the majority of Chinese exports, having a tendency toward a richer, bolder pattern which is more commercially valuable. Increasing concern about possible overexploitation led the CITES secretariat to call on member countries in April 1993 to refrain from further imports of leopard cat skins from China pending implementation of suitable control and management measures in that country. A project is currently underway to evaluate the species status and current management measures in China, and to advise the government on necessary improvements (see Project 13 in Part III).

The Biological Impact of Trade on Wild Populations

In general, it appears that cat populations are resilient to harvest up to a certain threshold ("maximum sustainable yield"), and offtake in excess of that threshold can lead to extirpation. The percentage of a population that can be harvested without producing an overall decline in numbers varies among species—for example, the bobcat has greater fecundity than the ocelot and can sustain higher offtake. Within a species, however, local environmental differences will lead to a variation in density across its range, so that a harvest rate appropriate for one area may be inappropriate for another. Changes in prey abundance will affect cat populations. Canada lynx are particularly vulnerable to over-harvest when their main prey species, snowshoe hare, go through cyclic declines. Thus, indices of abundance are of critical importance in developing sustainable harvest regimes, but these have proved difficult to develop for cats (see Chapter 3, Research).

Unfortunately, the impact of the past 30 years of international commercial trade will never be fully known for most species. For the spotted cats of Africa and Latin America, hunting was either illegal or unmanaged, so that the biological impact was never addressed. That none of the species involved have become extinct does not necessarily mean that the trade was sustainable. Important subpopulations may have been eradicated—or may not have—but at this late stage this issue will be difficult, if not impossible, to assess. Identification of areas subject to prolonged offtake remains very much local knowledge. Numerous hunter and trader accounts refer to local depletions (Myers 1975,1976, Koford 1976, Smith 1976, Hamilton 1981, Melquist 1984, Martin and de Meulanaer 1988). Evidence of local recovery (such as the ocelot in Venezuela: R. Hoogesteijn, pers. comm.) is anecdotal, and the current situation in areas previously subjected to intense hunting pressure has not been investigated. Moreover, the impact of habitat loss cannot be considered separately; populations that have been fragmented and isolated by human land-use patterns are particularly vulnerable to elimination.

Martin and de Meulanaer's (1988) attempt to simulate the impact of the fur trade on regional leopard populations in Africa was a thought-provoking exercise. Using a variety of data sources, they estimated the number of leopards killed annually in sub-Saharan Africa for the fur trade between 1950 and 1986 and, according to a leopard population model they developed, examined how large leopard populations would have had to be in order to survive the offtake. Figure 3 illustrates a first attempt to answer the question about the impact of this period of uncontrolled commercial exploitation of cats. In the case of northern Africa, the harvest was apparently so large that Martin and de Meulanaer (1988) had to double their estimate of the potential leopard population existing at that time in order to prevent its simulated extinction. However, the overall conclusion was that, based on population estimates predicted by their model, the fur trade had no serious lasting impact on the abundance of the species.

Only for two species—the Canada lynx and the bobcat—has the biological impact of commercial harvesting been a priority for study. These are relatively important species in the fur industry, and programs to manage commercial trapping are in place. An examination of the effectiveness of these management regimes is useful for assessing whether commerce can play a positive role in cat conservation.

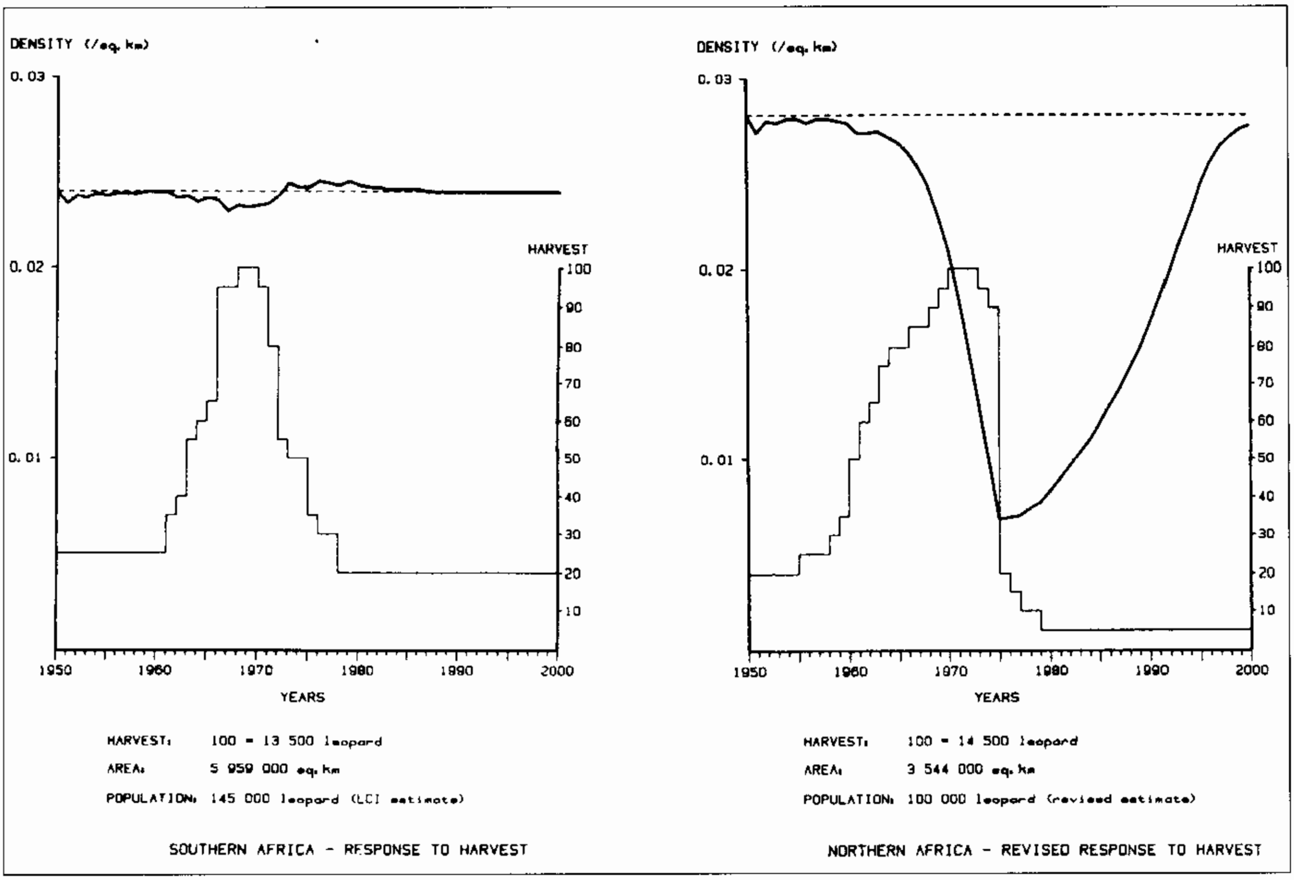


Figure 3. Predicted response to harvest of leopard populations in southern and northern Africa. Source: Martin and de Meulenaer (1988). [Southern Africa = Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia, and Zimbabwe; Northern Africa = Djibouti, Ethiopia, Somalia, and Sudan].

Sustainable Use of Cats for the Fur Trade: The North American Example

It would be inappropriate to review large-scale commercial trade apart from the context of harvest management policies (or lack of such) which make it possible. Basic components of the North American strategies are reviewed below. Similar information on Russian management of their Eurasian lynx harvest is not available, and China's high leopard cat harvest, with estimates of annual take between 1985-1988 as high as 400,000 (J. Yu *in litt.* 1991), is at present unregulated, although a project is underway to investigate biological impact and develop appropriate management controls (Johnson and Fuller 1992, Johnson *et al.* 1993).

Although the fur trade has posed a threat to some cat species, in the case of others it can be argued that it benefitted their conservation. The harvest and sale of felid pelts can be a component of a strategy to extract economic value from wildlands, providing a strong incentive, on both the local and national levels, to ensure their conservation. Canada and the United States have developed the most advanced management programs to date for commercial exploitation of feline furbearers. The following sections review North American management of commercial hunting of bobcat and Canada lynx, and examine to what degree these programs can be considered (1) examples of consumptive sustainable use of cats and (2) to support the conservation of these species. Any government which considers commercial exploitation programs for their cat species would be well advised to review the strong points and weak points of North American programs in the process of developing locally appropriate management practices.

Review of Bobcat and Canada Lynx Management Programs in the United States and Canada

In the United States and Canada, bobcat and Canada lynx populations are managed at the state, provincial and Indian nation levels, rather than by the national governments. In the U.S., the role of the national government is chiefly to ensure that the total amount of furs exported does not constitute an offtake which is detrimental to these species' survival, as required by CITES for trade in species listed in Appendix II (see Box 1). The Canadian government, on the other hand, has delegated this responsibility to the provinces (C. Dauphine *in litt.* 1994).

In the U.S., in the late 1970s, the Endangered Species Scientific Authority (the responsibilities of which were later transferred to the Fish and Wildlife Service), established the following biological information requirements to evaluate the adequacy of state bobcat management programs for export approval:

1. Population trend information, the method of determination to be a matter of state choice;
2. Information on total harvest of the species;
3. Information on geographic distribution of the harvest;
4. Habitat evaluation.

The minimum national requirements for bobcat management programs are:

1. Harvest should be controlled, the methods and seasons to be a matter of state choice;
2. All pelts should be registered and marked;
3. Harvest level objectives should be determined annually.

In Canada, each province sets its own information and management requirements. Quinn and Parker (1987) have suggested that the minimum information requirements should include the following:

1. The chronology of lynx harvest statistics and prevailing regulations relative to specific management regions;
2. The chronology of snowshoe hare abundance relative to specific management regions (i.e., small game license returns, questionnaires, etc.);
3. Assessment of the above to evaluate the magnitude and temporal trends of the lynx-hare cycle at regional levels;


Garth Mowatt

Radio-collared Canada lynx, Yukon, Canada, where studies of fur-bearing animals are being carried out.

4. Annual samples of lynx carcasses (collected from trappers) to assess sex and age structure and fecundity;

5. Results of (4) assessed relative to (1) and (2);

6. Annual collection of "winter lynx abundance indices" based on field personnel "impression" or from fixed winter track transects (e.g., specific vehicle, snowmobile or snowshoe routes);

7. Awareness by managers of all literature relative to lynx-hare cycles and an understanding of the principles that control lynx densities.

Most management programs in Canada and the U.S. include three basic components which are discussed below: (1) habitat evaluation and management; (2) assessments of population size, structure, and trends; and (3) harvest control and monitoring.

Habitat Evaluation and Management

The degree to which cat habitat is evaluated and managed varies widely by jurisdiction. In general, management authorities (1) evaluate and categorize types and qualities of cat habitat; (2) determine the distribution and amount of habitat in the various categories of quality; and (3) determine changes in the distribution and amount of habitat that might affect management.

The habitat use and habitat requirements of the two North American lynxes have been extensively studied (see Species Accounts), and in some cases, attempts have been made to translate study results into workable management tools. Habitat suitability guidelines and indexes have been developed (e.g., Boyle and Fendley 1987, Anon. 1991e). On the other hand, some jurisdictions (for example, several western states and provinces) assume that their entire management area is comprised of lynx or bobcat habitat of equivalent quality. Others define cat habitat on the basis of vegetation types or physiographic regions, and base their determination of habitat quality on some assessment of cat density within each habitat type. In the U.S., for example, South Carolina has defined three categories of bobcat habitat—coastal plain, piedmont, and foothill—based upon physiogeographic regions, and has defined habitat quality based on scent-station survey indices of bobcat abundance within each region (B. Baker, South Carolina Wildlife and Marine Resources Department *in litt.* to the USFWS Office of the Scientific Authority [OSA] 1988). Texas defines bobcat habitat as "all areas dominated by natural vegetation," and uses a state habitat map to determine the percentage of natural vegetation within each county in each of the state's 10 ecological regions. Bobcat density estimates are derived for each ecological region on the basis of a combination of harvest/population ratios and educated guesses (Bluett and Tewes 1988).

While varying degrees of effort go into evaluating cat habitat, it is rarely actively managed for the cats, despite a number of specific recommendations having been put forward (e.g., Allen 1987, Quinn and Parker 1987, Koehler and Brittell 1990). Generally speaking, cat habitat is managed in a variety of ways by a number of state, provincial, and national agencies with diverse briefs (i.e., state wildlife management areas, national forests, national parks, watershed conservation areas). Even where habitat management guidelines have been developed and officially approved, as for Canada lynx in Washington state (Anon. 1991e), implementation is spotty due to the fact that not all agencies whose jurisdictions include cat habitat are bound by them (S. Thorpe *in litt.* to USFWS 1991).

An example of recommendations for specifically managing habitat for cat conservation is Koehler and Brittell (1990) on the Canada lynx. They strongly recommended that forests be managed so as to maintain good snowshoe hare habitat—winter patches of successional vegetation for browse and relatively dense stands of trees for shelter. They point out that, with a few modifications, conventional forest management is compatible with lynx habitat management, including such practices as controlled burning, small patch (as opposed to extensive) clear-cutting, thinning stands to maximize tree growth potential, control of pests, and construction of logging roads. In the northwestern U.S., along the southern boundary of Canada lynx range, they also emphasize the importance of maintaining interspersed stands of old-growth forest, which lynx in this area use for denning. While they note that modifications to management practices, such as scheduling tree thinning either early (when snowshoe hares have not yet recolonized an area) or late (30-40 year old growth little used by hares), may result in an initial increase in management costs, these could be offset by greater economic and ecological diversity.

Assessments of Population Size, Structure, and Trends

To satisfy national biological information requirements, many provinces and states estimate the size of their cat populations. Most have approached the problem by conducting one or more radio-tracking studies to determine the various parameters needed to estimate population density in representative habitats (e.g., average home range size for males and females, extent of intra- and intersexual overlap in home ranges, and proportion of transients in the study population). The population density estimate for each habitat type (particularly important for the bobcat, a strong habitat generalist) can then be multiplied by the total area for each habitat to obtain a population total.

The accuracy of these population estimates depends upon both the accuracy of the habitat-specific density estimates and the accuracy of the extrapolation (Rolley 1987). Habitat-specific density estimates can be affected by the presence of uncollared resident cats in the study area (Rolley 1987); inaccurate estimates of home range size or overlap due to small sample sizes; or inaccurate estimate of the proportion of transients in the population. The accuracy of the extrapolation can be affected by inaccurate measurement of the total area of habitat in the jurisdiction or by applying a density estimate derived from one habitat to one that is dissimilar.

Management authorities attach particular importance to reliable information on population changes, especially population response to trapping. Some only monitor population trends, rather than estimate total population size. Because radio-tracking studies are costly, labor-intensive, and require many years to complete, managers seldom use them over the long term to monitor population changes. Instead, most use indirect indices of population levels, as described below.

The quality of population monitoring obviously varies among jurisdictions. Some do little more than monitor harvest. For example, the terrestrial wildlife manager for Colorado has reported: "While we do not have specific data on trap effort, track indices, bobcats observed, or other good population indicators, reports from both our field men and the involved public indicate no noticeable changes in population" (R.J. Tully *in litt.* to OSA 1989).

While a good deal of data has been collected on the population variables described below, numerous factors compromise their utility, and Rolley (1987) has suggested the use of at least two indirect indices to mitigate against uncertainty: confidence should increase if "several indices show the same trend." This is borne out by a comparison of bobcat density estimators (scent-station transects, monitoring of harvest levels, and radio-isotope feces tagging) with the number of bobcats known to be within a northeastern Florida study area over a two-year period as determined by radio-telemetry. Connor *et al.* (1983) found that all indices moved in synchrony with the radiotelemetry estimate (Conner *et al.* 1983). Many management authorities do in fact utilize multiple estimators. Minnesota, for example, uses mandatory harvest reporting, mandatory carcass collection to determine sex, age, and reproductive parameters, annual scent-station surveys, and computer modelling of population changes (Boggess *et al.* 1989).

Harvest Level and Harvest Effort

Changes in overall harvest or harvest effort (measured as catch per unit of harvest effort) can be used to help evaluate population status. Change in overall harvest is a crude, but still useful, indicator of abundance. For example, analysis of fur harvest records kept by Canada's Hudson Bay Company show a striking difference over time in the cyclical highs of Canada lynx harvest—from nearly 80,000 pelts per year in the late 1880s to about 20,000 30 years later, with a continued decline through 1940 (Elton and Keith 1946: see Fig. 6 in the Canada lynx Species Account). The period 1880-1920 was a time when western Canada was opening up, trapping was essentially uncontrolled, and there was intense competition for furs among unregulated trappers. Harvests only began to climb again in the 1960s, possibly reflecting an increase in lynx numbers following institution of management programs (Todd 1985).

However, change in harvest levels can be influenced by factors other than the size of the cat population. As Rolley (1987) has written: "Annual harvest estimates will reflect changes in population levels only if harvest pressure is relatively constant." Harvest pressure, however, is rarely "relatively constant," being influenced strongly by winter weather (Rolley 1987), number of trappers (Tewes and Scott 1987), and pelt prices (Erickson and Sampson 1978, Brand and Keith 1979)—harvest tends to increase with pelt price, although some evidence is contradictory (Govt. of Canada 1988).

Data on harvest effort collected by trapper interview—number of cats caught per trapper, number of trap-nights per cat, or number of cats per trap-night (Slough and Ward 1990, Tewes and Scott 1987, R. Eagan, pers. comm.)—can be a better index to population change because biases related to pelt price and total number of trappers are eliminated. The principal concern is the accuracy of the harvest effort measurement.

Age and Sex Ratio Changes

Patterns of, and changes in, age and/or sex ratios are often used as indices of population change. This is particularly true for cyclic Canada lynx populations. In Canada, most authorities routinely measure pelt size (tip of nose to base of tail) prior to auction to distinguish adults from young of the year, or kits (Quinn and Gardner 1984, Slough and Ward 1990, Poole 1992). Monitored on an annual basis, a peak in the proportion of kits in the harvest should precede a cyclic decrease in lynx productivity and a fall in the population size. However, time of collection can influence kit representation within the overall sample because the number of kits caught increases with the length of the trapping season (Parker *et al.* 1983, Quinn and Thompson 1985, Quinn and Parker 1987).

Some authorities collect carcasses from trappers. These carcasses can be sexed, and age can be determined by sectioning teeth and counting the rings of cementum annuli (Quinn and Parker 1987, Rolley 1987). Age-specific fecundity and mortality rates can be determined.

Several studies of bobcat and Canada lynx populations have pointed towards vulnerability to trapping which is both age- (yearlings may be more vulnerable to trapping as a result of their dispersal over unfamiliar areas) and sex-specific (males may be more vulnerable to trapping because their home ranges are larger and thus contain more traps) (for summary see Anderson 1987, Quinn and Parker 1987, Rolley 1987). Some models for estimating population size from the harvest have attempted to take such vulnerability into account (e.g., Paloheimo and Fraser 1981). However, disparities in age and sex ratios in the harvest must be weighed against the fact that age and sex ratios within the population can be strongly affected by density (Frederickson and Rice 1979, Lembeck and Gould 1979, Zezulak and Schwab 1979, Slough and Ward 1990). For example, more males than females in the harvest could reflect the presence of more males in the population, rather than simply greater male vulnerability to trapping.

Changes in Prey Availability

As discussed in the species account, throughout much of their range lynx populations fluctuate cyclically along with their main prey, the snowshoe hare, typically lagging one to two years behind. Several Canada authorities are researching the effectiveness of monitoring snowshoe hare abundance (through a combination of feces counts, track counts, and trapper interviews) as an index of lynx population change (Slough and Ward 1990, Poole 1992).

Changes in prey availability are also a pertinent index to bobcat populations in some areas. For example, Knick (1990) studied bobcats in Idaho at a time when lagomorph populations were declining, and found that bobcat numbers also declined.

Scent-station Surveys and Track Counts

These two methods of estimating population size, and their strengths and weaknesses, are discussed in the Research chapter.

Population Modeling

Management authorities have developed a variety of computer models to estimate changes in bobcat and Canada lynx populations which utilize field data collected by the above methods on population levels, productivity/recruitment, population age and sex ratios, and harvest and non-harvest mortality rates.

Harvest Control and Monitoring

Management of bobcat and Canada lynx harvest involves, for the most part, determination of allowable harvest levels and control of the harvest so that it does not exceed these levels. Management assumes that cat populations are at some equilibrium level below carrying capacity, and therefore produce a harvestable surplus.

Determining allowable harvest levels, or quotas, is an imprecise exercise. Some authorities use sophisticated computer models to determine the effects of various harvest rates on population parameters, including population size. An acceptable harvest rate is then selected—a rate which maintains the population at the pre-determined optimal level and allows for environmental fluctuations which may increase natural mortality or decrease recruitment and survival. Other authorities resort to "rule-of-thumb," "best guess estimates," or tradition to set harvest levels. For example, in the U.S., a year's quota is often set at the same level as the previous year's, especially if this level of harvest has been sustained over several years without a decrease in population indices. For the Canada lynx, annual quotas are set with regard to previous year's harvest and the current position of local populations within the lynx-hare cycle (Quinn and Parker 1987, Rolley 1987). It has been argued that it is not necessary to estimate population size prior to harvest commencement, but rather that harvest level can be adjusted according to population change indices (e.g., Slough and Jessup 1994).

While many jurisdictions calculate "safe" harvest levels, not all institutionalize these calculations as maximum allowable quotas. Canada lynx harvest is regulated by annual quota in Manitoba and parts of Ontario and Alberta (Canada), and Montana and Idaho (U.S.). Bobcat harvest is regulated by annual quota in Arkansas, California, Louisiana, Massachusetts, Minnesota, Montana, Oklahoma, Oregon, South Carolina, Tennessee, Virginia, West Virginia, and Wisconsin (U.S.), but nowhere in Canada. Quotas may take the form of total animals allowed caught per jurisdiction (i.e., 500 bobcats per year in Louisiana) or total animals allowed caught per person (i.e., in Ontario annual quotas are established per registered trapline through the cooperation of local wildlife officials and the trapper) (Govt. of Canada 1983, 1988; Govt. of U.S. 1983a,b; Johnson 1990, Koehler 1990).

Other forms of harvest regulation include manipulation of harvest season length and chronology, area of harvest, take methods, and licensing requirements. New regulations are promulgated from time to time, and are usually published well in advance of the open season. All jurisdictions set a season length for harvest of bobcat and Canada lynx (both for hunting and trapping), generally in winter (November to February), so as to avoid taking breeding adults and immatures. If harvests are felt to have been too high in recent years, management authorities may close their season indefinitely, either in the whole or part of their jurisdiction. Some jurisdictions prohibit trapping in certain areas which serve as refugia from which cats can disperse to recolonize hunted areas. Licensing requirements vary widely, from the simple purchase of a season license in some U.S. states to more complex legal systems of long-term leasing (five-year terms in the Yukon) of registered trapping concessions in some Canadian provinces (Govt. of Canada 1983, 1988; Govt. of U.S. 1983a,b; Todd

1985, Slough and Jessup 1994).

Harvest monitoring is accomplished by a variety of methods. Both the U.S. and Canada require that pelts destined for international export be tagged with nationally approved tags; many jurisdictions require that all pelts be tagged. Some jurisdictions require that all carcasses be submitted for examination of age, sex, and reproduction; in others, this is voluntary. Some management authorities require certain information from trappers, hunters, or both (e.g. Idaho requires all licensed trappers to prepare an annual report); others require registered fur dealers to report.

Are Canada Lynx and Bobcat Harvests Sustainable as Presently Managed?

IUCN has recently drafted a set of guidelines to help define when the use of a wild species is sustainable (IUCN in prep). According to their criteria, a use of a wild species is likely to be sustainable if:

1. It does not reduce the future use potential of the target population or impair its long-term viability;
2. It is compatible with maintenance of the long-term viability of supporting and dependent ecosystems;
3. It does not reduce the future use potential or impair the long-term viability of other species.

Since rare species are seldom trapped incidentally to Canada lynx or bobcat, and since habitat management for these cats (where practiced) is compatible with conventional forest management, the last two criteria are satisfied.

With regard to the first criterion, the American and Canadian governments have invested substantial effort in ensuring that harvest levels do not reduce the viability of their bobcat and lynx populations. Annual reported harvests for bobcat and Canada lynx over the past 15 years are presented in Figures 4 and 5. For the bobcat, the primary period of concern was the late 1970s to early 1980s. Prior to this, bobcat pelts had little value (the average pelt price from 1950-1970 being only U.S. $5-10: Young 1958), and bobcats were generally considered pests. Harvest levels greatly increased following the entry into force of the American Endangered Species Act in 1969 and CITES in 1975, when the pelts of cats listed on Appendix I were barred from legal trade, and the value of bobcat pelts increased to hundreds of dollars (see Species Account). The U.S. government temporarily banned export of bobcat pelts in 1977 pending evidence to indicate that harvest levels were not detrimental to the survival of the species, prompting state governments to develop and institute harvest management programs, and leading to a huge increase in field research on the species (Blum and Escherich 1979, Anderson 1987).

Similarly, Canada lynx pelt prices increased over the same period. During the cyclic low in lynx populations in Canada in the mid-1970s, provincial harvests were up to three times higher than during the preceding two cycles. However, during the peak in lynx abundance in the late 1970s-early 1980s, provincial harvest levels were 40-70% lower than during the preceding peak (with the exception of the Yukon and Northwest Territories, where the peak harvests were slightly higher, although this probably relates more to increased trapping pressure than to actual population increases: Todd 1985, Govt. of Canada 1988). This was a reversal of the apparent recovery trend of Canada lynx since the early 1960s. A similar trend, on a smaller scale, has been documented in the American states of Washington and Montana (S. Thorpe *in litt.* to USFWS 1991). Moreover, the highest prices historically recorded for lynx pelts (up to U.S. $750 per pelt) were offered in the mid-1980s, when lynx populations again were at their cyclic low, and harvests again were high (Govt. of Canada 1988).

Todd (1985) considers various factors that could account for the reduced peak lynx harvest, including habitat loss, severe winter weather, and declines in snowshoe hare numbers, but concludes that the most likely explanation is overtrapping during the cyclic low. At this time, overharvest would theoretically reduce the breeding population necessary to regenerate a peak, and thus produce an overall decline in lynx abundance (Brand and Keith 1979). Shortening or closure of harvest during cyclic lows has been called for (Berrie 1973, Brand and Keith 1979, Carbyn and Patriquin 1983, Parker *et al.* 1983, Todd 1985, Bailey *et al.* 1986, R. Eagan, pers. comm.), and this recommendation has been implemented in parts of some states and provinces (Govt. of Canada 1988). However, Poole (1994) believes that stopping trapping during periods of low hare densities in the Northwest Territories is not necessary. His evidence suggests that trapping during at least the first two winters of low hare densities may be partly compensatory, as trapping of lynx likely to starve would have little impact on the population. In addition, a significant portion of the entire community trapping area appears to be buffered from trapping and may provide substantial refuges for population recovery.

An alternative management strategy involves maintenance of refugia in good-quality habitat to ensure protection of breeding lynx nuclei during cyclic lows. This strategy would appear more appropriate for areas where there is no evidence for significant lynx population declines, such as north-western Canada. Studies to identify and define such refugia, and investigate their role in lynx trapping areas, are ongoing in the Yukon and Northwest Territories (Slough and Ward 1990, Poole 1994). Poole (1994), for example, has found that a signif-

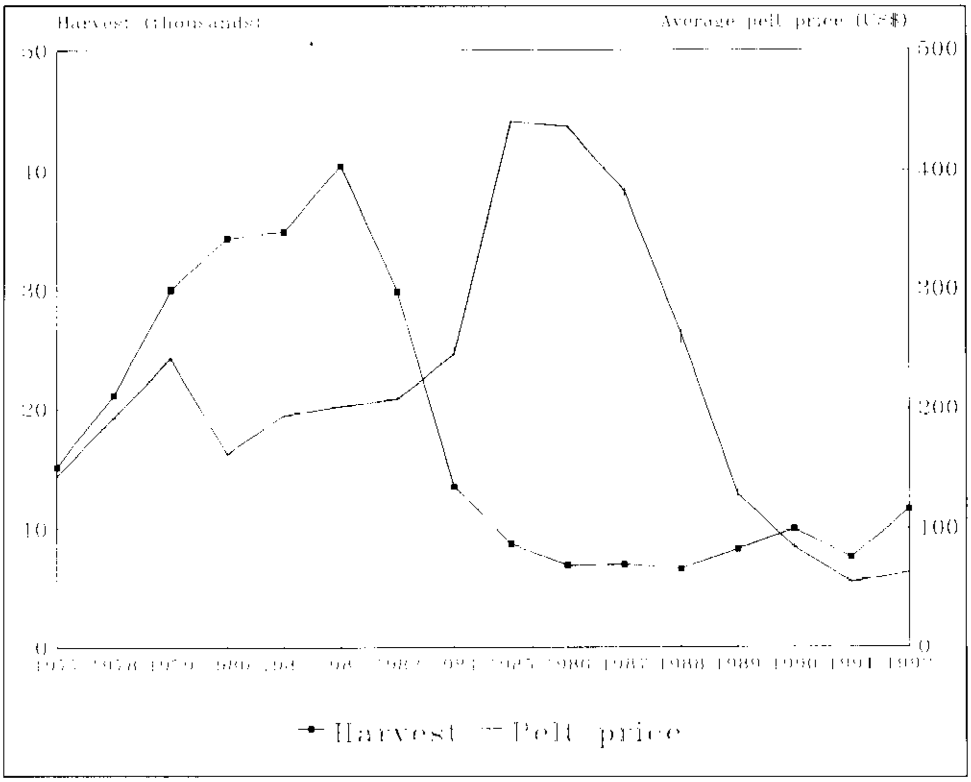


Figure 4. Annual harvest and average pelt price for the lynx in Canada. Source: Canadian Wildlife Service, Statistics Canada, and TRAFFIC U.S.A.

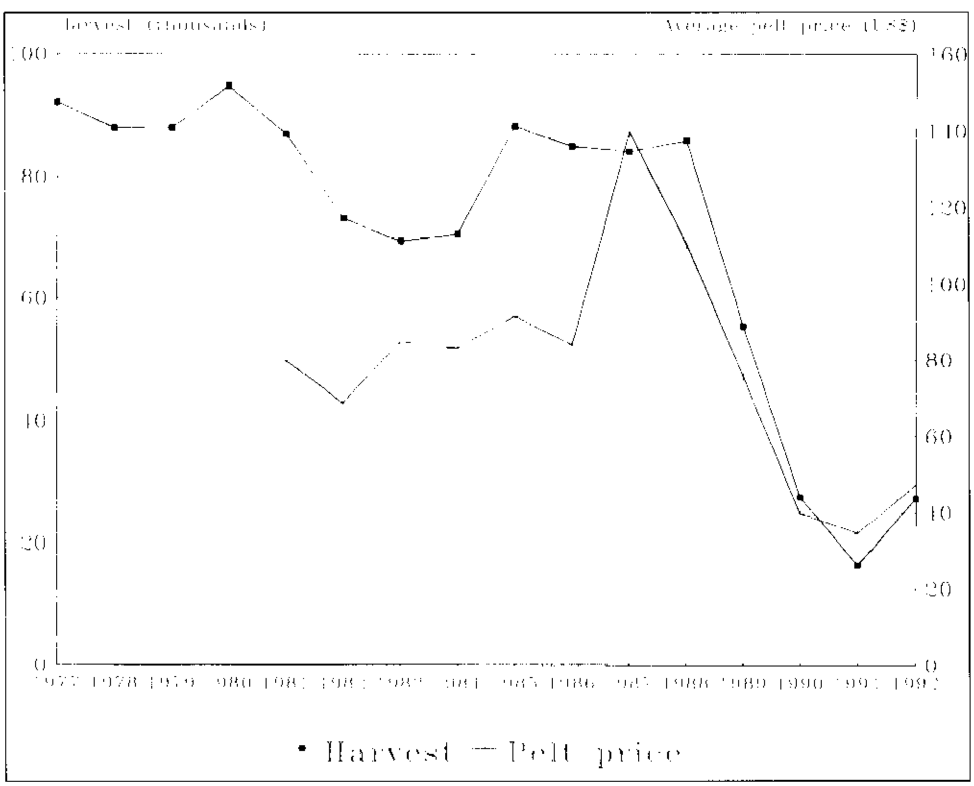


Figure 5. Annual harvest and average pelt price for the bobcat in the U.S. Source: U.S. Fish and Wildlife Service and TRAFFIC U.S.A.

icant portion of his community trapping study area in the Northwest Territory is apparently buffered from trapping, due to natural features and other factors, and thus provides a substantial refuge for population recovery.

Management of North American lynx and bobcat harvest has thus been adaptive—both harvest and population levels are monitored, and regulation of exploitation is made more restrictive if evidence arises to indicate that use is potentially unsustainable. Research has been an integral part of resource management, and management and population/harvest monitoring techniques have become progressively more refined and sophisticated. This is one of the requirements defined by IUCN (in prep.) for management for sustainable use: "A management system is needed that is able to adapt and adjust uses in response to changes in the target population, its supporting ecosystems, and other affected species. Such a system recognizes that all the information needed to ensure sustainable use may not be available. It therefore sets use levels cautiously and adjusts them in response to monitoring and other sources of information."

While biological knowledge and management resources for the Canada lynx and bobcat far outstrip those of any other cat-countries in the world, they are still not sufficient to yield the information needed to guarantee that harvests are sustainable—reliable periodic population estimates. Given the difficulties of counting cats (see Chapter 3, Research), however, such estimates are likely to remain unavailable for some time. Yet it is probably safe to say that current North American management practices have resulted in sustainable harvests in that they have been sufficient to prevent widespread and prolonged overharvest. Under such a management regime, the long-term viability of both cat species is unlikely to be impaired, and the commercial use of bobcats and Canada lynx can thus be considered sustainable. Additional system refinements are needed for better insurance against local population depletion, however, such as appears to have occurred in some southern populations of Canada lynx.

A number of suggestions have been put forward for improvement of management practices (Brand and Keith 1979, Todd 1985, Bailey *et al.* 1986, Quinn and Parker 1987, Rolley 1987, Govt. of Canada 1988, Knick 1990, Tewes and Scott 1987). These authors acknowledge that harvest regulation is a jurisdictional responsibility, but nonetheless recommend a certain degree of standardization, including the following:

1. There should be simultaneous application of harvest strategies over broad eco-regions.
2. In the case of the Canada lynx, trapping seasons should be closed or shortened during cyclic population lows, or a protected refugia strategy should be implemented. Knick's (1990) computer models indicate that refugia could play an important role in maintaining harvested bobcat populations, as well.
3. All harvests should be regulated at the appropriate level (trap-line, state- or province-wide) and established by analysis of biological and survey data. However, quotas may not be necessary for cats in remote areas where trapping pressure is more dispersed (or, for the Canada lynx, at least not during years of high recruitment).
4. Harvest monitoring procedures should be standardized. It has been suggested that (a) all jurisdictions should collect age/sex data from pelt measurements and carcasses by standardized procedure to gauge the status of the population and, in the case of the Canada lynx, its position in the hare-lynx cycle; (b) all jurisdictions monitor trapping effort and trapping success. Tewes and Scott (1987) suggest that the responsibility for monitoring harvest in the U.S. should be decentralized to the county or management unit level.
5. Harvest reporting should be standardized, particularly in the U.S.
6. All pelts should be tagged or sealed within the jurisdiction of harvest, and taxes/royalty rates should be standardized to discourage illegal inter-jurisdictional movement of pelts for the purpose of avoiding higher tariffs.

If a use is sustainable and long-term population viability is not affected, the question of whether the use is conducive to species conservation is not relevant. However, not only is there sufficient room for doubt regarding the biological impact of past harvests on numbers of Canada lynx and bobcat but, at present, world demand for these cats' fur is declining (Table 1). Under such circumstances, it is important to ask whether commercial use can be considered to support the conservation of these species.

Does Commercial Use Benefit Bobcat and Canada Lynx Conservation?

Fur trapping entails removal of animals from wild populations and can benefit these populations if it serves as an incentive to relieve other population-reducing pressures, primarily habitat loss. IUCN (in prep.) recognizes that "the social and economic benefits from sustainable use could provide powerful incentives to conserve wild species and their supporting ecosystems, providing that (1) the people most likely to have a direct impact on the species and ecosystems concerned receive a fair share of the benefits from the use; and (2) there is a clear connection between the benefits and conservation" (e.g., "a portion of these benefits should be reinvested in maintaining target populations and their supporting ecosystems").

The furs of the bobcat and Canada lynx are among the most valuable of North American furbearers (Shieff and Baker 1987). When prices were at their highest in the mid-1980s, the trade in Canada lynx pelts provided some U.S.$3,800,000 directly to trappers (Canadian Wildlife Service *in litt.* 1994). As Todd (1985) pointed out, the capture of even one Canada lynx represented a significant contribution to a trapper's income. Even for the bobcat, or for the lynx in the current low-price market, cat fur revenues are still relatively significant. In the 1987-1988 California trapping season, for example, the average per trapper income from an average harvest of 13.5 bobcats came to just under U.S.$2,000 (Gould 1989). Do such revenues serve as an incentive for trappers to actively support cat conservation?

The answer to this question is equivocal. Looked at one way, the answer is "no." The highest pelt prices offered for Canada lynx were at a time when the population was at its cyclic low, a basic function of supply and demand, and there is justifiable concern that over-trapping has reduced populations. People often place short-term gain over long-term interest: in the words of Todd (1985), "even the most conscientious registered trapper may be tempted to over-trap lynx when they are valuable, despite hoping for the sake of the lynx that the price will go down soon." This is why government regulation is necessary to avoid overharvest.

On the other hand, hunters and trappers form an important powerful constituency for conservation of wildlands in both Canada and the U.S. License revenues and other tariffs derived from cat hunting also contribute to the budgets of government agencies charged with ecosystem conservation.

There have been no studies examining to what degree either consumptive or nonconsumptive use values of cats translate into effective cat conservation. As with the value of sport-hunted cats, the commercial value of North American cat pelts is unlikely to be a major force for cat conservation if viewed in isolation from other values, including the existence value many people place on wild cats, as well as other wildland-derived economic revenues. However, those who derive commercial benefit from the harvest of North American cats are among the group which lobbies for actions contributing to the conservation of these species.

Illegal Trade in Cat Products

Illegal trade takes place when legal trade is restricted or prohibited but some degree of consumer demand remains. When that demand is strong, it is very difficult to prevent trade through legal controls alone—the resilience of the drug trade is a good example. It is unlikely that banning import of spotted cat pelts into Europe would have been so successful had it not been for a major decline in demand. Illegal wildlife trade remains a serious problem even for the United States, where CITES issues are accorded relatively high priority by the government. The U.S. Fish and Wildlife Service has estimated that for every 10 wildlife shipments entering the country legally, one to four enter undeclared and undetected (Grove 1981). In 1988, 65 inspectors were faced with the task of inspecting more than 83,000 declared shipments of wildlife for compliance with a number of national regulations as well as CITES regulations. In reality, the inspectors only managed to inspect about 25 percent of the declared shipments (Mulliken and Thomsen 1990).

The significance of illegal trade in cat products is shown by the following example. In 1990, the majority of exports of tiger bone medicines reported by China were to the United States. Although the United States prohibits import of tiger bone, neither import nor seizure was reported in 1990 (Headley 1992).

Illegal trade in cats and their products generally assumes three forms: trade in live animals as pets, trade in pelts or body parts (claws, teeth, etc.) for fur garments or novelties, and trade in bones and other body parts for Oriental medicine. Of the three, the latter is probably the most serious. Demand for the first two categories is probably relatively low and unlikely to be increasing. Tourists make up an important proportion of consumers.

It is more difficult to evaluate demand for bone from the medicinal trade because, as will be discussed below, a basic understanding of the dynamics of the consumer market is lacking. Demand may be increasing given the recent reports of tiger poaching from India and Nepal, but it may also be decreasing or unchanged—the poaching in the Indian subcontinent does not necessarily indicate a change in consumer demand, but could reflect widespread depletion of supply. In other tropical Asian tiger range states, tiger conservation is not of such high priority and poaching incidents are less likely to gain media attention. The status of the tiger in these countries is highly uncertain.

Medicines containing tiger bone or other cat bones are used primarily by Chinese and Koreans. Consumers are not limited to these two countries, however, but are found throughout the world, mainly where there are Oriental communities.

Of all the threats facing cats, illegal trade has the greatest potential to do maximum harm in minimum time. Commercial poaching can be devastating to species—witness the well-documented cases of the black rhino and African elephant. The existence of commercial poaching and illegal trade indicates product demand, but when the product is illegal, it can be very difficult to learn enough about the nature of the demand to take appropriate correc-

Tiger and leopard skins seized from illegal traders in Calcutta in 1989.

tive measures [illegible] trade was relatively visible [illegible] to be worn. Consumer [illegible] were also relatively obvious [illegible] the magnitude of the [illegible] reducing demand [illegible] Reduction of [illegible] Illegal trade in [illegible] sale usually [illegible]

[illegible]

bone, it does not necessarily follow that they will reduce or eliminate demand—on the contrary, black market "mystique" could actually increase consumer interest if trade bans are not strictly enforced. The use of cats by the Oriental medicine trade is one of the biggest challenges posed to cat conservation today.

The three categories of illegal trade in cats and their products are reviewed below, and the threat posed to different species assessed. Most cats are traded illegally to some degree, but in many, if not most, cases the animal was killed for other reasons—livestock protection, intolerance, opportunism—and the trade is a by-product of the action. In general, systematic, illegal, commercial exploitation of cats has greatly decreased since the early days of the international fur trade.

Illegal Trade in Pelts and Live Animals

The legal trade in cat furs is currently declining, and there-

Claude Levinson

Skins displayed in Tachilek on Myanmar frontier with Thailand in 1994.

is little evidence in the former consuming countries of Europe, North America, and east Asia of significant demand for garments made from species which were once popular, and are now protected (such as the leopard or ocelot). However, there is still evidence of illegal trade in pelts in many of the range states with spotted cats. In Latin America, large shipments of pelts are occasionally confiscated. For example, 675 pelts, mostly oncilla, were seized en route from Paraguay by Brazilian authorities, and were incinerated in February 1991 in Iguaçu National Park (P. Crawshaw, A. Ximénez *in litt.* 1991).

Montevideo (Uruguay) and Buenos Aires (Argentina) were major centers of the illegal fur trade in Latin America up until the early 1990s. The main felid furs in trade were obtained from Geoffroy's and pampas cats. Since 1990, there has been a significant improvement in the enforcement of international trade controls in both Argentina and Uruguay. Illegal trade in the furs of these species has decreased dramatically as a result. However, very small internal markets for fur items persist in Montevideo and Buenos Aires, in spite of legislation banning the sale of furs of these species. Dealers involved in the illegal trade employ various tactics to make the garments they sell appear old, and therefore not subject to government sales controls. One method involves sewing labels from old European fur garments into garments offered for sale; another involves invoicing buyers of fur coats for a "repair" rather than a "purchase" (J. Villalba-Macias, *in litt.* 1993; Tomas Waller, pers. comm. 1994).

In Europe, open sale of coats made from cat furs appears to be restricted to Greece. Greece did not join CITES until 1993, but prior to that it was nonetheless required, through membership in the European Union, to enforce EU CITES regulations. TRAFFIC Europe (de Meulenaer and Gray 1992) surveyed fur shops in several major Greek cities, and found coats made from Appendix I cats in over 100 of them. Many garments were made from small spotted fur scraps, but others were made from full pelts. Species in trade included ocelot, leopard, cheetah, and jaguar. While TRAFFIC states that some of these skins may have been imported legally, they were concerned about the lack of monitoring by Greek authorities. Traders did not help to allay suspicions by proposing several ways of avoiding controls (de Meulenaer and Gray 1992).

The consumer market consists largely of tourists, of which Greece is host to some 10,000,000 annually. TRAFFIC notes that this is particularly worrisome for EU-wide enforcement of CITES: with internal border controls being removed, each member state becomes a potential door to the entire EU market.

In Asia, Kashmir has long been a center of fur processing (van den Berg and Damhuis 1982, Verma 1983, Chopra 1988, Mohapatra 1988). Coats made in Kashmir from snow leopard, leopard, clouded leopard, fishing cat, leopard cat, jungle cat, wildcat, and rusty-spotted cat have been found for sale recently to tourists in Kathmandu, Nepal, in a Kashmiri-run fur district (Barnes 1989, van Gruisen and Sinclair 1992). As in Greece, traders provided advice on how to avoid western import controls. In China, the fur tanning industry in the northeastern city of Harbin is similar to that in Kashmir, and well processed skins of leopard and Asiatic golden cat have been found for sale there (Low 1991).

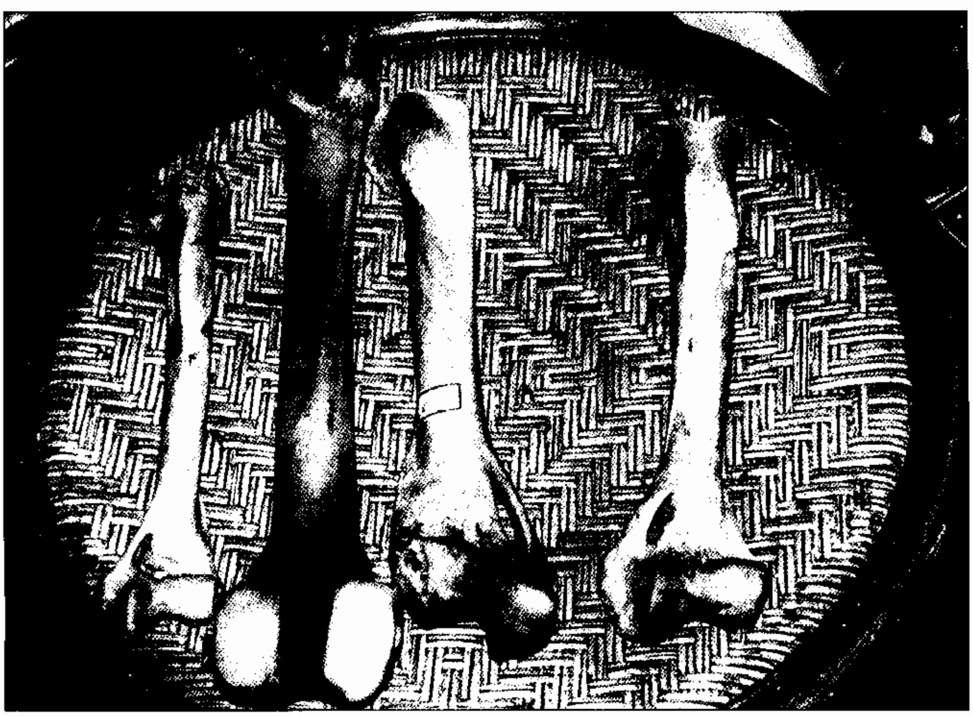
Skins of protected cats and live wild-trapped animals, both typically in poor condition, can be spotted in wildlife markets around the world. This trade, while illegal, is often highly visible, especially to visiting conservation-minded westerners, and the Cat Specialist Group has received numerous reports from dozens of countries, rich and poor. Because hunting intensity varies locally, it is difficult to draw any conclusions about the overall impact of this trade on cat populations. In general, however, these markets are more likely to reflect local levels of persecution of cats (for livestock protection, sport, opportunity, occasional income, etc.), rather than systematic commercial poaching of the sort that is now being directed at the tiger, as discussed below.

The Bones of a Dilemma: Tigers and Oriental Medicine

Ancient Chinese medical texts dating back some 2,000 years proclaim that tiger flesh improves vitality and is a talisman against 36 kinds of demon. Tiger fat is a cure for hemmorrhoids. Tiger blood builds up the constitution and strengthens the willpower. Tiger testes treat scrofula. Tiger eyes clarify the vision and stop crying. Hung from the roof, its nose will induce the birth of boys. Officials wore the "majestic bone" (or clavicle) of the tiger around their necks to give them poise and inspire the envy of the common people. Tiger whiskers cure toothache. There are many uses for tiger bones, with curative powers for a diverse range of complaints from rat-bite sores to hydrophobia, but chiefly having to do with building strong bones and teeth. Sliced and ashed, bones taken from tiger feces cure alcoholism—in November 1992, the tiger enclosure of the Taipei Zoo saw an upsurge of demand from wives anxious to end their husband's chronic drinking (K. Nowell, pers. obs.). Tiger penis makes tigers of men (Read 1982, Martin 1987).

Modern Chinese pharmaceutical texts do not dwell on such claims, and discuss only tiger bone, prescribed mainly to alleviate symptoms of rheumatic and bone marrow disease (Anon. 1976). Tiger bone is often combined with other ingredients to make a plaster for aching joints and sore muscles. Small portions of ground tiger bone are mixed with liquor to make tiger bone wine, which is more of an invigorating tonic, with aphrodisiacal overtones, than a medicine.

Tiger bone is marketed in two ways. Traditionally, bones are stocked by pharmacies and doctors, and small portions are sliced off and ground on the spot for patients. Leg bones are favored, particularly the humerus—proba-



K. Nowell

Two tiger humerus bones at right show foramina (holes for nerves and blood vessels) at the distal ends, which are distinctive of big cats. Third from the right is a femur bone. At left, the smaller humerus may be from a leopard, a species also used in traditional Oriental medicine.

bly not only because these are the more "powerful" prey-catching limbs, but because the humerus has a large foramen (an opening allowing the passage of blood vessels and nerves) at its distal end, distinctive to the family Felidae, which permits the authentic to be distinguished from the fake. In Taiwan, wholesale prices for such bones ranged between U.S. $860-1,280 per kg (about five humeri) in October 1992 (Nowell 1993a, b). Traditional Oriental pharmacies, which stock a variety of herbs and animal parts, are found throughout east Asia and in overseas east Asian communities throughout the world, which number some 29,000,000 people (Anon. 1992k).

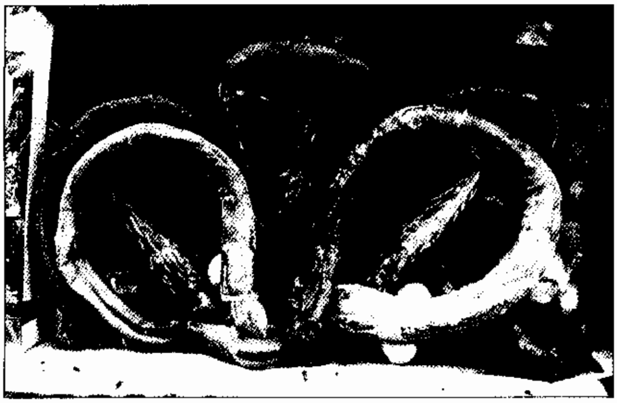
The second, more modern form, is in manufactured medicines, including pills, powders, and wine. Up until 1994, China and South Korea were the chief producers. China's annual reports to CITES over the 1980s and early 1990s indicate exports to Hong Kong, Malaysia, Singapore, Thailand, and the United States. Hong Kong, which plays a key middleman role in China's traditional medicine trade, is consistently reported as the major exporter of tiger products seized in the U.S. (Headley 1992).

However, in the face of threats of trade sanctions from CITES Parties and from the United States, China announced in May 1993 that it would ban production of tiger bone medicines, at that time manufactured by more than 20 companies in over 100 factories (Tan 1987, X. Liu *in litt.* 1992), following a six-month grace period. The South Korean government also announced prohibition of domestic trade in tiger bone in May 1994, with a ban on production to take effect in November, and a ban on sale of tiger bone products to follow six months later. They claimed that all tiger bone stocks in the country had been identified and registered as of March 1994 and individually marked by the government in May (J. Thomsen *in litt.* June 1994).

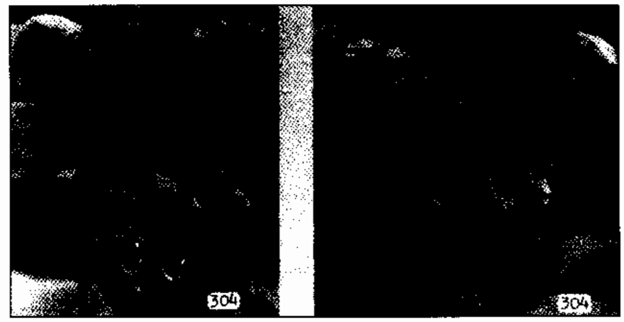
Although nearly every Asian range state has protected its tigers from hunting and banned international and internal trade in their products, medicines labelled as tiger bone have been found for sale throughout the region (Tan 1987, Martin 1992a,b, Anon. 1992i), as well as in many western countries. Poaching is widespread, commercialized, and driven by the bone trade. For example, in India, tiger carcasses have been found with the bones removed and the skins left behind (S. Dey, pers. comm. 1992). According to C. McDougal (*in litt.* 1991), bones are sold in Bangkok at prices 10 times higher per kg than pelts. The threat goes beyond the tiger to encompass other Asian cats: the bones of leopard, snow leopard, clouded leopard, golden cat, and leopard cat are sold as substitutes for tiger bone (Tan 1987, J. Yu *in litt.* 1991, R. Jackson, pers. comm.).

Peter Jackson

Tiger specialists in 1995 examining canine teeth made into pendants in a Hanoi curio shop.



Tim Redford



Tim Redford

Many fake tiger parts are offered for sale, such as these penises at Tachilek in Myanmar (left). Above, the genuine article is depicted in a Chinese publication (Lin, H. and Chen, S. 1988).

Unfortunately, the tiger bone trade has not been systematically investigated, and its organization and dynamics are largely a puzzle. For example, sources in India and Nepal identified China as the destination for tigers poached in these countries (Martin 1992c, Anon. 1992i). The medicinal manufacturers would seem to be the obvious culprit. On the one hand, the Chinese government has claimed that all stocks of tiger bone used by the manufacturers were obtained prior to 1981, when China joined CITES, which permits legal export of their medicines as "pre-Convention." On the other hand, the government has confessed that it cannot "calculate exactly how much tiger bone is used in our country at present," nor "exactly how many factories are producing medicines which include tiger bone" (X. Liu *in litt.* 1992). However, it is obvious that new stocks of tiger bone have entered the country since 1981. Smuggling of tiger parts from Burma to China was reported from as early as 1983 (Salter 1983, Anon. 1984), and Tan (1987) reported that the medical industry was paying what was then considered a very high price of U.S. $200 per kg for Burmese tiger bone.

Yet reaching simple conclusions about the ultimate destination of poached tiger bone is difficult because what is sold as "tiger bone" is often not genuine. Oriental medicine has its skilled practitioners, but also its share of charlatans. Faking valuable natural medicinal ingredients is something of an art form, and the Chinese have devoted a full color photo textbook to distinguishing the false from the real (Lin and Chen 1988). The book's photos clearly show that products which are marketed as tiger parts (and have been reported as such by investigators) are actually taken from cattle. This includes "tiger" penis and "tiger legs"; the latter can be easily found in China sold by "Tibetan" street peddlers, and are put together from cattle bone and ligaments, a bit of striped orange fur, and dog claws. They have been seen in Taiwanese traditional pharmacies where the proprietors were clearly taken aback to learn that they were fakes (K. Nowell, pers. obs.). The price of an item marketed as a tiger derivative is not necessarily an indication of its legitimacy, but rather of the seller's audacity.

Moreover, the Wildlife Forensics Laboratory of the U.S. Fish and Wildlife Service has tested more than 10 samples of Chinese-manufactured "tiger bone" plasters and powders, and found that the products actually contained no bone of any kind (E. Espinoza, pers. comm. 1993). This finding not only complicates law enforcement, but points out how little is understood of the tiger bone trade. It is not at all clear how much tiger bone—or other wild cat bone—is actually being used to produce manufactured medicines. Chinese industry sources have reported that it takes 250 g of tiger bone (roughly the weight of a humerus) to manufacture 55 kg of tiger bone wine (Tan 1987). While no official import statistics for "raw tiger bone" are available from China, customs data from South Korea shows average annual imports of 340 kg between 1975 and 1992, at an average price of U.S. $127 per kg (J. Mills 1993). According to traders in southeast Asia, the yield of dried bone from a single tiger ranges from 6-11 kg (Anon. 1992i), which implies that South Korea imported the equivalent of 557-1,021 tigers over 18 years (if the bones were really tiger bone).

However, with the supply of wild tigers declining, perhaps real tiger bone is being diverted to the more traditional pharmacies, where discrimination of fakes is somewhat easier. In October 1992, real tiger bone was being sold in the main wholesale district in Taipei, Taiwan in October 1992 (Nowell 1993a, b). Following publicity campaigns launched by several western environmental groups, the Prime Minister held a press conference to reiterate that trade in tiger bone has been banned since 1989, and called for better law enforcement. According to

Sanjay Kumar

Tiger bones seized in Delhi in 1993.

TRAFFIC Taipei, all bone of any sort soon disappeared from shop windows (J. Loh, pers. comm. May 1993).

However, deciding that Taiwan had still not effectively closed down its internal market, the U.S. government announced in April 1994 that it would enact limited trade sanctions against Taiwan, as authorized by the so-called "Pelly Amendment" to the Fishermen's Protection Act of 1967, which provides for the President to prohibit importation into the U.S. of wildlife products from an offending country if advised that the nationals of that country are engaging in trade or taking which diminishes the effectiveness of any international program for endangered or threatened species. The Taiwan government responded by establishing a special police task force, something long called for by local conservationists. Agents made a total of 7,704 undercover visits to traditional pharmacies, and found only 50, or less than 1%, selling tiger bone. The government issued special public awareness stickers (written in both Chinese and English, for the benefit of Western critics) to pharmacists who signed a written declaration that such products were not for sale in their shops. Legislation to increase penalties for illegal trade in wildlife products was sent to the Legislative Yuan. The American government recognized Taiwan's progress in curbing illegal trade by dropping the Pelly sanctions a year later, in July 1995.

The tiger poaching situation has been likened to the early days of rhino poaching, when no one realized how severe and thorough a commercially driven poaching crisis lay ahead (Jackson 1991b). In the case of rhino horn, trade bans led to international trade being taken over by criminals and speculators. They inflated the price of the horn, and the added cost was passed on to patients by the doctors and pharmacists. (The 1980s were a period of significant economic growth for Asia, the main consuming market.) Publicity regarding the endangered status of the rhinos appeared to influence speculator interest in acquiring horn "before it's too late," which further fueled poaching. This faceless but powerful segment of the market may actually be its driving force—investing in the rhino's extinction, thus inflating demand above actual levels of consumption, which may be quite low. Given that rhino horn does not have to be displayed in order to be prescribed, law enforcement is difficult. Meanwhile, while the Asian medical community is generally aware of the rhino's endangered status, it stubbornly defends the use of its horn as an important medicine for serious illnesses only (Nowell *et al.* 1992, Milliken *et al.* 1993).

To what extent does the market for tiger bone resemble that for rhino horn? On the one hand, unlike rhino horn, tiger bone is not considered a potentially life-saving medicine. However, like rhino horn, genuine tiger bone is a high-priced, "charismatic," long-lasting commodity suitable for investment by speculators, if they believe the market will persist despite its illegality.

At present, the internationally favored solution to crises of commercial poaching has been to ban the trade, and to attempt to reduce demand through publicity campaigns. This approach was successful for the African elephant and for the spotted cats of the southern hemisphere. Its effectiveness has not yet been demonstrated for species used by the Oriental medical trade, which is an entirely different sort of market. Trade bans alone are unlikely to be effective if demand persists.

How strong is the demand for tiger bone? What sort of people are the main consumers, and why do they take it? How would they react to (a) a campaign emphasizing the tiger's endangerment; (b) a campaign to promote substitutes for tiger bone (if indeed there are any); or (c) news that manufactured tiger bone medicines are fake? The point is that a better understanding of consumer demand and the marketing channels is needed before an effective strategy for change can be developed. It is not enough that the tiger's rarity has been the focus of media attention (Anon. 1992l, Browne 1992, Hamer 1992, Anon. 1993i, Hennessey 1993, S. Mills 1993, Tiger Trust 1993, Linden 1994), and that most major consuming nations are rushing to demonstrate their goodwill by banning the trade. Indeed, there is the danger that publicity and "black market mystique" could make the problem worse, as for the rhino.

Although the Chinese government banned trade and production of tiger bone medicines in 1993, in 1994 it revived a request made to CITES in 1992 for recognition of the first commercial captive breeding operation for the Amur tiger. Recognition would allow it to market tiger products derived from captive tigers internationally. The proposal, to have been submitted to the ninth Conference of the Parties to CITES in November 1994, involved sale of bones and other derivatives obtained from tigers which died or were culled at a breeding center at Hengdaohezhi in Heilongjiang Province. The proposal was again withdrawn, this time before being officially circulated to the Parties. Because the issue keeps resurfacing, it is worth a brief discussion.

The Chinese proposal stated that tiger parts would be cumulatively obtained from "culled and dead individuals" and is ambiguous about how they would be sold, but the premise is that "limited legal trade of the derivatives and products of the tiger will reduce the poachers' desire on the wild population" (Govt. of China 1994). Recent articles in *Asiaweek* (Anon. 1993i) and *Time* (Linden 1994) magazines have mentioned the idea of supplying the tiger bone market from captive animals. A glance at the subsequent letters to the editors showed that while westerners are generally outraged by the idea, east Asians, particularly Chinese, are more supportive. Tiger farms exist in Thailand with openly commercial aims: one owner stated recently that, "Our scientific research will look into the possibility of using tigers as farm animals, breeding them the way we breed pigs" (Anon. 1994d). In fact, it is likely that there are more tigers in captivity (including "unofficial" institutions) than in the wild, and tigers are breeding so well in recognized zoos (see Chapter 5) that "surplus" tigers are not infrequently euthanized. If the recent trade bans and proposed consumer education campaigns do not alleviate the tiger poaching crisis, so that the decline towards extinction of the tiger in the wild continues, the conservation community may be faced with an unpleasant dilemma: whether or not to breed tigers for their bones in order to save the remnant wild population.

Summary and Conclusions

1. The fur trade is not a serious threat to spotted cats for the foreseeable future. The only species that can be said to be threatened by potentially unsustainable exploitation for the fur trade is the leopard cat, and then only in China. A CITES project is currently underway to study the ecology of the leopard cat to aid evaluation of its status, and to examine harvest practices in China in order to advise the government on development of a sustainable management program (Johnson and Fuller 1992, Johnson *et al.* 1993; see Project 13 in Part III).

2. The North American example has demonstrated that commercial trade in cat furs can be sustainable, and can help to conserve cat habitat as part of a strategy of making wildlands an economically competitive form of land use. Management strategies should continue to include funding for a strong component of research, and should continue to evolve to reflect new understanding of species biology (Project 98).

3. Illegal trade in pelts persists in many range states, but the areas which produce garments made from protected species are few in number, and the customers appear to be mainly tourists. With regard to the sale of cat fur coats in Kathmandu, Van Gruisen and Sinclair (1992) have pointed out that a small-scale publicity campaign aimed at tourists would be a relatively simple to carry out, and could be highly effective.

4. The Oriental medicine trade poses a grave threat to the tiger, and commercial poaching could well lead to its virtual extinction in the wild within a decade. Anti-poaching protection for tigers should be increased, but market forces will probably continue to dictate the status of wild tiger populations. Project 12 includes trade surveys to provide better understanding of market organization and consumer demand, so that effective strategies for bringing the tiger bone trade under control can be developed.

Part II
Major Issues in Cat Conservation

Chapter 5
Cats in Captivity

Introduction

Cats have been kept in captivity for thousands of years, and have served various human needs, some utilitarian (such as hunting rodents for pest control, or antelope for sport) and others less so (the use of cats as pets, emblems of status, or as a spectacle for public entertainment). They have always been among the most popular exhibits in zoos. It is only recently, however, that keeping cats in captivity has come to be perceived as something which not only benefits humans, but also cats themselves. Interest in contributions which the *ex situ* (off-site—i.e., in captivity) zoo community can make to *in situ* (in the wild) conservation has greatly expanded over the past two decades. Major zoos are evolving from menageries, whose animals were collected chiefly for entertainment and display, to conservation centers, with an important role to play in public education and wildlife conservation (Fig. 1). In terms of conservation, zoos generally place the greatest emphasis on their efforts to maintain viable populations of threatened species, which can potentially serve as seed stock for reintroduction in case of extinction in the wild, or for revitalizing depleted populations.

This chapter reviews the status and management of cats in captivity with specific reference to conservation of cats in the wild. Ways are recommended for the zoo community to strengthen its role in cat species conservation.

A Brief History of Cats in Captivity

The most obvious testament to cats' historical popularity with humans is the housecat, which was domesticated from the African wildcat. Ancient Egyptian art reveals that cats were fully domesticated by 1,500 BC, but the domestication process clearly got underway much earlier, although there is little archaeological evidence (Pocock 1907c, Clutton-Brock 1981, Davis 1987, Serpell 1988, Hemmer 1990). Recently, archaeologists have found a cat's jawbone amidst ruins in Cyprus dating from about 6,000 BC. No cats are native to the island, and the find indicates that the first human colonists brought their cats with them (Serpell 1992).

Domestication was probably a gradual process at first, with wildcats developing a symbiotic relationship with humans based on rats and mice, which then as now would have been pests in homes and stores of food (Zeuner 1963, Serpell 1988). It would be difficult to say when the domestic cat became fully tame, or adapted to life in captivity rather than in the wild. Perhaps it hasn't yet: the housecat has been termed the only "semi-domesticated" mammal in recognition of its retained ability to feed itself, as well as its notorious reluctance to obey commands (Clutton-Brock 1988). While the housecat's behavior has not been totally altered by a captive environment, selective breeding has produced great changes in its appearance. Most of this "un-natural selection" has taken place over the last century (Serpell 1992): Darwin (1868) mentioned that there were only two distinctive types of domestic cat in Britain (the Persian and the Manx), but there are now 27 officially recognized "races" and 3,667 color varieties (Feline International Federation *in litt.* 1993). The morphological, behavioral, and genetic differences between domestic cats and wildcats deserve further study, and could help to illuminate the effects of captivity on other felid species kept for future reintroduction to the wild (see Chapter 6, Reintroduction).

Apart from the notable example of the domestic cat, the historical record is sketchy with regard to small cats in captivity. The ancient Egyptians appear to have trained jungle cats to hunt without really domesticating them (Morrison-Scott 1952). Marco Polo (1299) reported that Kublai Khan kept hunting caracals, as did some Indian princes, a practice which continued in India into the early 20th century (Allen 1919a, Sharma and Sankhala 1984).

Big cats have long been popular in captive collections. The Romans displayed lions, tigers, and cheetahs in menageries, pageants, and arena combat (Toynbee 1973). Cheetahs were tamed and trained to hunt by early rulers

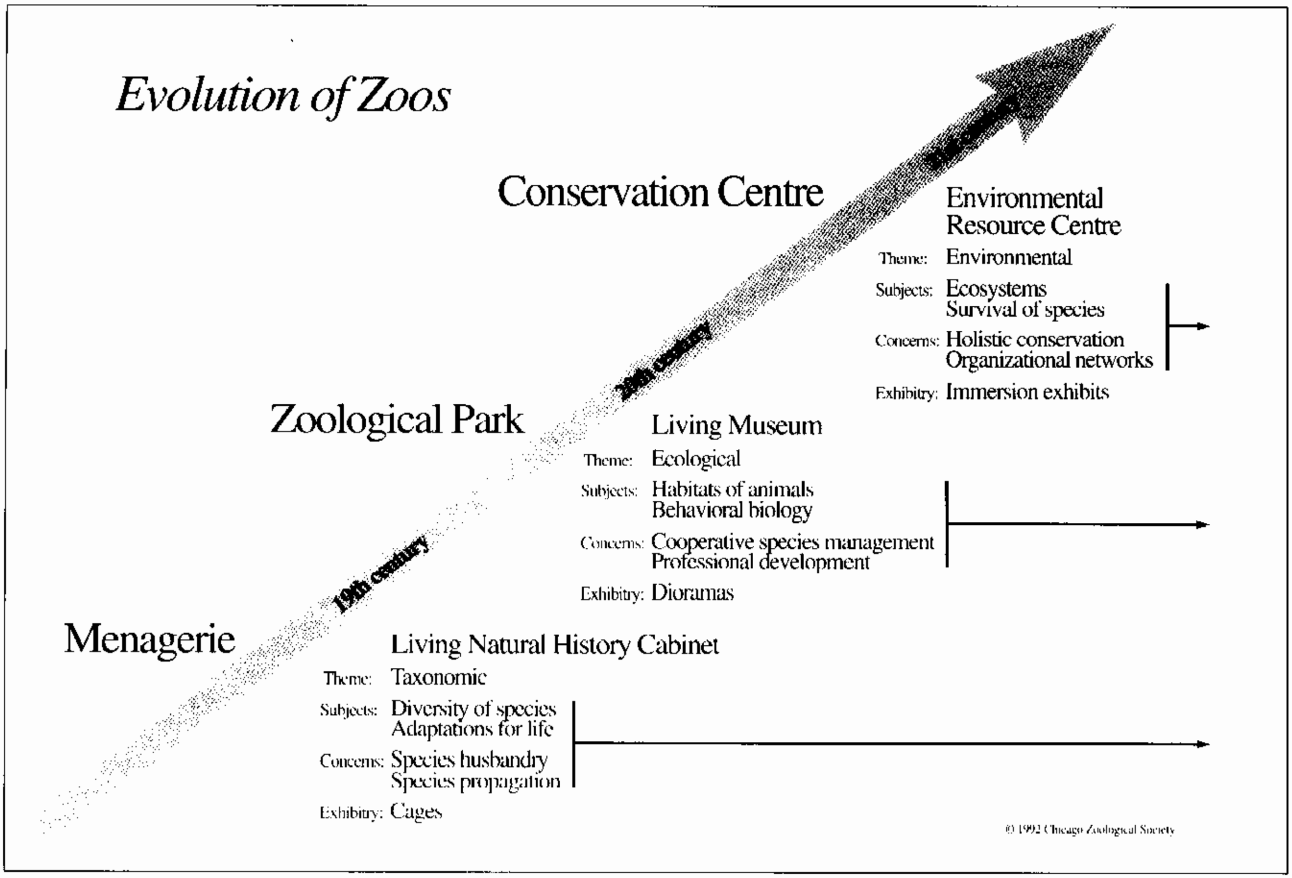


Figure 1. Evolution of Zoos. Adapted from G. Rabb's figure in WRI/IUCN/UNEP (1992).

of Palestine, Egypt, Assyria, Persia, Russia and the Caucasus (Vereschagin 1959, Guggisberg 1975), and also, according to Marco Polo, by the court of Kublai Khan. This tradition reached its zenith during the time of the Moghul emperors in India (1500-1800s) (Divyabhanusinh 1984). One 16th century emperor, Akbar, was reported by his son, Jehangir, to have kept 9,000 cheetahs in his lifetime (Abu Faz-l 17th century), with over 1,000 held at one time in his menagerie (Alvi and Rahman 1968). Tigers were a popular animal in aristocratic collections in Asia for centuries (Courtney 1980), and may also have been trained to hunt by early Chinese emperors, long before the Mongol invasion (Guggisberg 1975). Big cats have at times been obliged by the powerful to serve as executioners. The practice was not limited to the Romans—tigers were so employed by Asian rulers, as well as pumas by the Incas (Guggisberg 1975).

While people were proficient at keeping cats in captivity, breeding them was a more difficult task. Regarding both Akbar's and his own collection of cheetahs, Jahangir noted, "He was very eager that they should pair, but this in no way came off. Several times the male and female hunting leopards were brought together unchained in the gardens. But there too they did not pair. Recently it happened [after Akbar's death] that a male slipped off its collar, approached a female and paired with it. After two and a half months three cubs were born. They grew up. As it appeared strange the event was recorded." He made a similar observation regarding Akbar's collection of tigers: "It was just a freak that a tigress became pregnant and after three months bore three cubs. Else, it has never happened that a wild tigress paired with its male in captivity" (Alvi and Rahman 1968, D. Chavda *in litt.* 1993).

Lack of successful breeding in captivity was probably a major cause of the extinction of the Indian cheetah by the early 20th century, as live-trapping of cheetahs was a major industry in the late 1800s (Sterndale 1884, Divyabhanusinh 1984). An additional factor was that only wild-caught adult cheetahs hunted successfully, but not juveniles. The Alipore Zoo first imported an African cheetah in 1892, princely imports began in 1918 (D. Chavda *in litt.* 1993), and by the late 1920s, Finn (1929) reports that import of African cheetahs for the royal collections had become a regular practice.

Table 1
World Zoo Associations

Africa (15 zoos)
Regional association: Pan African Association of Zoological Gardens, Aquariums, and Botanic Gardens (PAAZAB)

Asia (545 zoos)
National associations in: China, India, Indonesia, Japan, Pakistan, Thailand

Regional association for southeast Asia: South East Asian Zoo Association (SEAZA)

Australasia (30 zoos)
Regional association for Australia and New Zealand: Australasian Regional Association of Zoological Parks and Aquariums (ARAZPA)

Central and South America (100 zoos)
National associations in: Brazil, Colombia, Mexico, Venezuela

Regional associations: Central American Zoo Organization and Latin American Association of Zoological Gardens and Aquariums

Europe (300 zoos)
National associations in: Britain and Ireland, Sweden, Denmark, Netherlands, Germany (plus Austria and Switzerland), Poland, Italy, France, Spain, Hungary

Regional association for Europe: European Association of Zoos and Aquariums (EAZA)

North America (175 zoos)
National associations in: Canada

Regional association for the subcontinent: American Zoo and Aquarium Association (AZA)

Total: 1,165 zoos

At the global level there is one single zoo organization: IUZDG—the World Zoo Organization.

Sources: CBSG 1993, IUDZG/CBSG (1993)

Whereas zoos and menageries throughout history were primarily stocked by wild-caught animals, the entry into force of the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) in 1975 (see Chapter 4) meant that from then on international trade in most species of wild cat was prohibited, except under very special circumstances. Public exhibition is considered a commercial use, and so zoos began to focus on ensuring the sustainability of their captive populations through breeding programs, which involve inter-zoo exchanges of individuals selected according to their bloodline. Over 90% of new animals registered in ISIS zoos (see below) are now obtained through captive breeding (Flesness and Foose 1990).

Status of Captive Populations

There are probably well over 10,000 zoos around the world (institutions which exhibit non-domestic animals to the public: IUDZG/CBSG 1993). At present, however, comprehensive data are available only from approximately 1,100 zoos organized into national, regional, or international federations. These federations and their membership are shown in Table 1.

Data on cats held in zoo collections (Fig. 2) are derived from the International Species Information System (ISIS), which contains data on species kept by over 400 zoos (December 1992). ISIS data are incomplete—less than 40% of the organized zoos register their collections, and there are problems with irregular reporting. ISIS data are biased toward large zoos in developed countries, and do not include information from specialized private breeders. For example, in comparison to the numbers presented in Figure 2, the 1991 International Cheetah Studbook (Marker-Kraus 1992) reports a captive population of 1,006, and the Tiger Global Animal Survival Plan (Tilson *et al.* 1992) reports 1,075 tigers. Similarly, P. Quillen (*in litt.* 1993) reports that there is a significant population of oncillas in private hands and in non-ISIS zoos. However, only ISIS data have been used in order to be consistent regarding the relative representation of species in captivity. The World Zoo Conservation Strategy (IUDZG/CBSG 1993), which recommends ways in which the zoo community can expand its role in species conservation, emphasizes the necessity of improving data collection within the community.

Examination of the data shows that, with regard to species vulnerability, the status of captive populations parallels the status of research effort described in Chapter 3, in that the big cats are disproportionately represented. The average size of captive populations of the eight species weighing over 20 kg is 491, ranging from a minimum of 144 (clouded leopards) up to 887 (tigers). The average population size of the remaining 21 species is 72, ranging

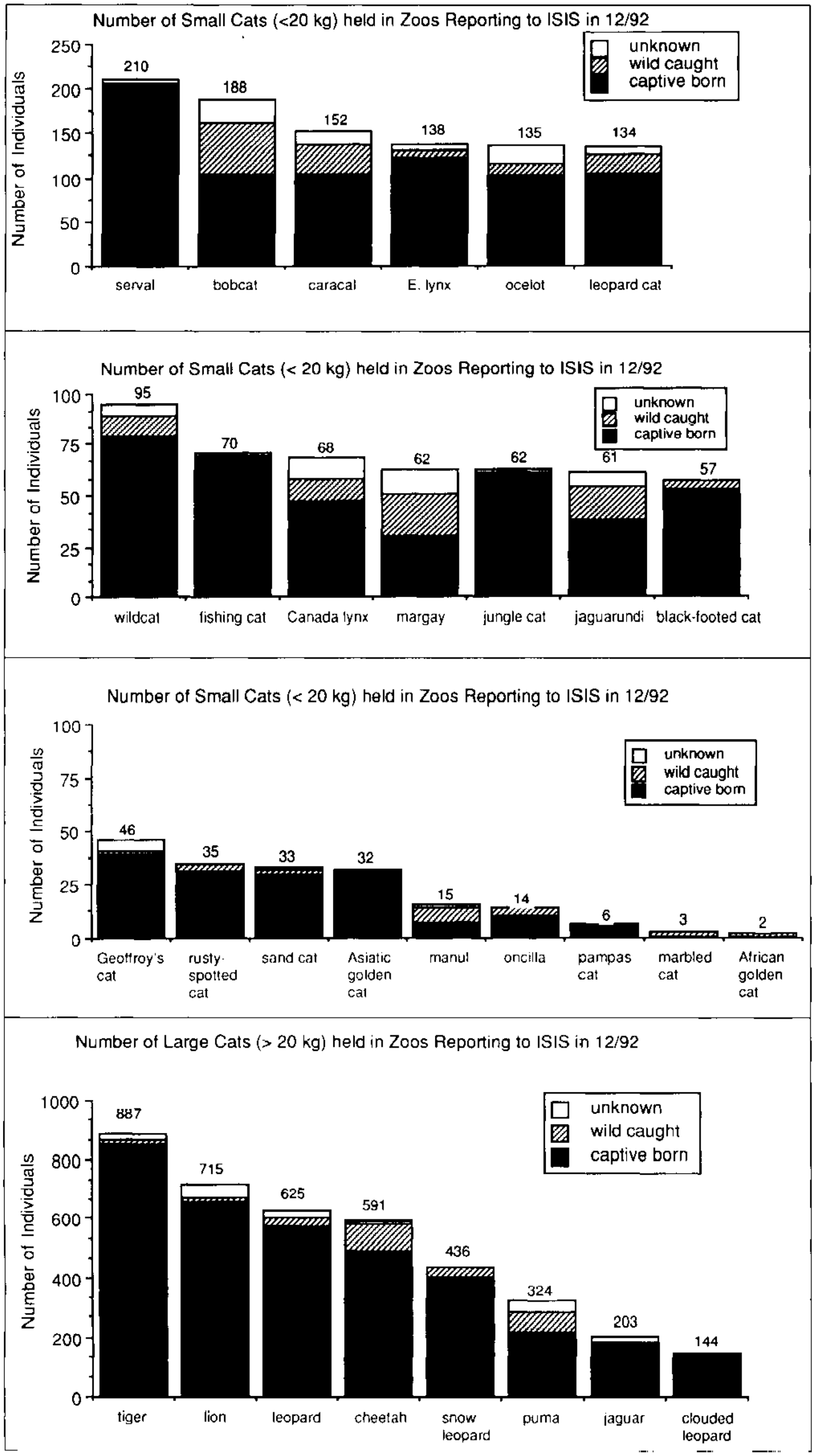


Figure 2. Representation of felid species in zoo collections in December, 1992. Source: Jill Mellen, Co-chair, Felid Taxon Advisory Group, American Zoo and Aquarium Association.

from 210 servals to two African golden cats. The vulnerable small to medium-sized cats (Categories 1-3) are under-represented. Six out of 13 species are not kept in captivity according to ISIS data (Table 2), and the average population size of the seven that are is just 30. With the exceptions of the fishing cat and black-footed cat, there are really no significant *ex situ* populations of these cats. Study of these species is a priority recommendation of this Action Plan. Knowledge of the ecological requirements and status of these species will help to determine whether any individuals should be removed from the wild for the purpose of establishing "insurance" populations in captivity.

International trade in live cats also parallels their representation in captivity (Table 3). That annual trade in the big cats is so high, particularly for the tiger and lion, reflects the size of the "unofficial" captive populations kept outside the major zoos and the breeding success that has now been achieved. Much of the trade in these two species involves travelling circuses and menageries (WCMC unpubl. data).

Another problem facing the management of *ex situ* populations is that most captive breeding programs follow guidelines which segregate animals according to established geographic origin or to recognized subspecies. Individuals of questionable status—"generic animals"—should technically receive lower priority for breeding than individuals of known origin (Ryder *et al.* 1988, Wildt *et al.* 1992a), although Willis (1993) points out that this could lead to a decrease in genetic diversity. The issue of recognition and classification of intraspecific diversity continues to be debated within the zoo community, and is discussed with regard to wild populations in Chapter 3. Table 4 shows that a high percentage of individuals from most captive cat populations are generic animals. Out of 28 species maintained in captivity for which there are data on founder origin, more than two-thirds (n=20) have a generic component greater than 60%. This problem is particularly acute for the small cats, although the high figure for the lion is striking.

On the positive side, the well-represented bigger cats are increasingly better managed; as discussed below, captive breeding and population management programs are at various stages of development for all these species. Management of these species as global populations is very important, for at present regional captive populations are very diffuse, with individuals scattered among an average of 126 zoos. Several of the smaller species are also coming under the management of these programs.

Moreover, for years members of the cat family have been fortunate enough to occupy the "lion's share" of the limited enclosure space available to Carnivores. Foose and Seal (1986) showed that at the end of 1981, about half of the 5,640 carnivores registered in ISIS were felids, and of these 60% were big cats of the genus *Panthera* (including the snow leopard). A survey to determine the amount of space available to carnivore species in North American zoos (Mellen *et al.* 1992) shows that cats occupy about 50% of carnivore cage space (n=1,889 spaces), and are also projected to occupy a similarly disproportionate share (47%) of spaces to be added within 5-10 years (n=322 spaces). Within the cat family, more than 70% of current and future space is allocated to cats weighing over 20 kg and a substantial portion is taken up by relatively common species (e.g., lynx, bobcat, puma).

Like wild habitat, captive habitat, or enclosure space, is in limited supply. Various estimates have been put forward as to how many viable populations of species could be supported in the world's captive habitat—which altogether amounts to only some 80 km^2 (Wiese and Hutchins 1993). These estimates generally indicate that there is room for no more than 1,000 species in viable numbers of at least several hundred individuals (Soulé *et al.* 1986, Flesness and Foose 1990, Wiese and Hutchins 1993). However, again the cats are allotted more than their "fair" share. Seal and Foose (1992) estimate that the felid sections of the world's organized zoos have the capacity to house at least 11,000 cats, and possibly double that. If the lower figure is accepted, this would permit maintenance of 36 species in populations of 300 or, looked at another way, 220 subspecies in populations of 50.

Reproduction in Captivity

Species Bred in Captivity

Most cat species have been bred in captivity, but with varying levels of success. This information is presented in Table 5. Exceptions include the Bornean bay cat and Andean mountain cat, which have not—as far as is known—been maintained in captivity. The Chinese mountain cat is kept in several Chinese zoos, but has not bred

Table 2
Cat Species Not Represented in ISIS Zoos

Bornean bay cat, *C. badia*
Chinese mountain cat, *F. bieti*
Iberian lynx, *L. pardinus*
Kodkod, *O. guigna*
Andean mountain cat, *O. jacobitus*
Flat-headed cat, *P. planiceps*

(Tan Bangjie *in litt.* 1993). The first breeding center for the Iberian lynx has been established at the Doñana National Park in southern Spain. The founding population consists of two young females (three years old) and an older male (7-8 years old). These animals cannot be returned to the wild—the females due to injuries, and the male because he was captured as a cub and raised in captivity. No breeding has taken place so far: although the females showed obvious signs of estrous behavior in the spring, the male showed no interest (M. Aymerich *in litt.* 1993).

The large cats, particularly lions and tigers, have generally reproduced well in captivity. For more than 15 years, many zoos have used contraceptives to limit reproduction of their big cats. The most common of these devices are synthetic progestagen (melangestrol and megestrol) implants. However, research (Munson and Mason 1991, L. Munson in prep.) is linking these implants to uterine lesions that may cause permanent infertility (severe endometrial hyperplasia and endometrial polyps) or even death (uterine cancer).

Reproduction in captivity has been problematic for two of the bigger cats: the cheetah and the clouded leopard. Developing guidelines to improve reproductive performance in cheetahs has been the subject of a good deal of focused research as well as wide-ranging surveys over the past few years (Grisham 1988, Marker-Kraus *et al.* 1990, Lee 1992, McKeown 1992, Lindburg *et al.* 1993, Fitch-Snyder in press, N. Wielebnowski in prep., S. Wells in prep., J. Grisham in prep.), including a major effort by the Cheetah Species Survival Plan to assess the reproductive status of 128 captive cheetahs in North America (Wildt *et al.* 1993a). This effort is bearing fruit: the number of successfully reproducing cheetahs in North American zoos has increased by 66% (to 53) since 1986. Of all cheetah births since 1956 in North America, more than one-third have taken place since 1986 (Marker and O'Brien 1989, Marker-Kraus and Grisham 1993).

Of the 79 clouded leopards listed in the International Clouded Leopard Studbook in 1986, less than 20% of adult females and 27% of males had reproduced (Wildt *et al.* 1986a). Research into the management and husbandry requirements of the clouded leopard is only just beginning, but the main problem is mate incompatibility, often fatal. The best solution seems to be establishing pairs when the animals are still sexually immature (Yamada and Durrant 1989).

In general, reproduction of the smaller cats (<20 kg) in captivity has been inconsistent (Mellen 1989, 1991, 1992, 1993). Many regional captive populations are highly inbred (Mellen 1989, 1993; G. Foreman, P. Quillen, pers. comm.), including Geoffroy's cat, rusty-spotted cat, pampas cat, fishing cat, wildcat, and African golden cat. In a study examining environmental components as potential correlates to reproductive success, 20 species of small cats

Table 3
CITES-reported International Trade in Live Cats, 1976-1990

Species	Annual Average Trade
Tiger, *P. tigris*	239.8
Lion, *P. leo*	145.1
Leopard, *P. pardus*	82.8
Cheetah, *A. jubatus*	61.0
Puma, *P. concolor*	26.5
Eurasian lynx, *L. lynx*	23.9
Jaguar, *P. onca*	23.1
Canada lynx, *L. canadensis*[1]	22.8
Serval, *L. serval*	20.7
Caracal, *C. caracal*	20.4
Wildcat, *F. silvestris*	16.3
Snow leopard, *U. uncia*	15.5
Leopard cat, *P. bengalensis*	13.1
Bobcat, *L. rufus*	10.3
Ocelot, *L. pardalis*	8.2
Clouded leopard, *N. nebulosa*	8.0
Jungle cat, *F. chaus*	5.0
Black-footed cat, *F. nigripes*	3.8
Geoffroy's cat, *O. geoffroyi*	3.7
Asiatic golden cat, *C. temmincki*	2.9
Manul, *O. manul*	2.4
Sand cat, *F. margarita*[2]	1.9
Oncilla, *L. tigrinus*	1.9
Margay, *L. wiedi*	1.7
Jaguarundi, *H. yaguarondi*	1.5
Fishing cat, *P. viverrinus*	1.5
Rusty-spotted cat, *P. rubiginosus*	0.8
Marbled cat, *P. marmorata*	0.7
Flat-headed cat, *P. planiceps*	0.5
African golden cat, *P. aurata*	0.5
Chinese mountain cat, *F. bieti*	0.2
Pampas cat, *O. colocolo*	0.2
Kodkod, *O. guigna*	0.2

[1] The annual average is inflated because 80 lynx in 1989 were exported from Canada to the U.S. for reintroduction into New York state. Canada reports exporting 140 animals to the U.S. in 1990; there may be an error in the data.

[2] The annual average is inflated by a shipment of 20 animals from Pakistan to Germany in 1977. Trade over the remaining period amounts to only eight animals.

Table 4
Animals of Unknown Subspecies/Origin in ISIS Zoos in 1989

Species	Vulnerability Ranking	Total Population	Percent [Number] Unknown Species/Origin	
Fishing cat, *P. viverrinus*	2	25	100%	[25]
Pampas cat, *O. colocolo*	5a	10	100%	[10]
Marbled cat, *P. marmorata*	3	4	100%	[4]
Ocelot, *L. pardalis*	5a	97	96%	[93]
Jaguarundi, *H. yaguarondi*	5c	44	93%	[41]
Geoffroy's cat, *O. geoffroyi*	4	36	92%	[33]
Jaguar, *P. onca*	3(A)	208	91%	[190]
Manul, *O. manul*	4	9	89%	[8]
Serval, *L. serval*	4	161	87%	[140]
Caracal, *C. caracal*	5b	104	86%	[89]
Clouded leopard, *N. nebulosa*	3(A)	116	85%	[99]
Lion, *P. leo*	3(A)	522	79%	[414]
Leopard cat, *P. bengalensis*	5b	36	78%	[28]
Jungle cat, *F. chaus*	5b	27	78%	[21]
Black-footed cat, *F. nigripes*	2	38	76%	[29]
Oncilla, *L. tigrinus*	3	4	75%	[3]
Asiatic golden cat, *C. temmincki*	3	27	74%	[20]
Bobcat, *L. rufus*	5a	170	73%	[124]
Puma, *P. concolor*	5a(A)	240	65%	[156]
Margay, *L. wiedi*	4	65	64%	[48]
Cheetah, *A. jubatus*	3(A)	318	42%	[135]
Leopard, *P. pardus*	5a(A)	577	29%	[169]
Rusty-spotted cat, *P. rubiginosus*	3	12	25%	[3]
Eurasian lynx, *L. lynx*	5a	47	17%	[8]
Tiger, *P. tigris*	2(A)	847	12%	[104]
Wildcat, *F. silvestris*	5c	28	7%	[2]
Canada lynx, *L. canadensis*	4	60	0%	—
Sand cat, *F. margarita*	4	13	0%	—

housed in eight zoological institutions were evaluated (Mellen 1991). Variables that correlated significantly with successful reproduction included housing no more than one male and one female together; relatively few medical problems (i.e., healthy cats); and a high level of keeper-animal interaction.

In a related study, the effects of hand-rearing on subsequent ability to copulate was examined (Mellen 1992). Results suggest that cats which have been human-reared in a traditional zoo nursery setting are less likely to copulate successfully as adults. On the other hand, adult reproductive success does not appear to be compromised in cat species that were human reared in a rich and varied environment (J. Mellen, pers. obs.). This suggests that the hand-rearing procedures of zoos should be re-evaluated, and should include provision of companions and a more "interesting" environment.

Zoos have made significant strides toward establishing and maintaining self-sustaining captive cat populations. However, zoos need to increase the representation of most small cat species, and especially the rarer ones. The future viability of present populations is tenuous without the addition of new animals, and it would be unwise to seek to remove animals from the wild before research into their status and ecology has been carried out. Instead, there should be more cooperation between zoos in different regions of the world in order to take full advantage of all animals presently held in captivity. The program now being established for tigers (see below: Tilson *et al.* 1992)—the culmination of many years of interest, data collection, and international communication—is a good example of how this cooperation should unfold. Other ini-

Table 5
Captive Propagation Status of Cat Species[1]

Species	Bred in Captivity	Raised Young	2d Generation Births	Self-Sustaining?[2]	References
Cheetah, *A. jubatus*	Yes	Yes	Yes	Yes	1
Caracal, *C. caracal*	Yes	Yes	Yes	Yes	1, 2
Asiatic golden cat, *C. temmincki*	Yes	Yes	Yes	No	1, 2
Jungle cat, *F. chaus*	Yes	Yes	Yes	Maybe	1, 2
Sand cat, *F. margarita*	Yes	Yes	Yes	No	1, 3
Black-footed cat, *F. nigripes*	Yes	Yes	Yes	No	13
Wildcat, *F. silvestris*	Yes	Yes	Yes	Maybe	1, 4
Jaguarundi, *H. yaguarondi*	Yes	Yes	Yes	No	1, 2
Ocelot, *L. pardalis*	Yes	Yes	Yes	Yes	1, 2
Oncilla, *L. tigrinus*	Yes	Yes	Yes	No	1, 5
Margay, *L. wiedi*	Yes	Yes	Yes	Maybe	1, 6
Serval, *L. serval*	Yes	Yes	Yes	Yes	1, 6
Canada lynx, L. canadensis	Yes	Yes	Yes	Yes	11
Eurasian lynx, *L. lynx*	Yes	Yes	Yes	Yes	11
Iberian lynx, *L. pardinus*	No	No	No	No	12
Bobcat, *L. rufus*	Yes	Yes	Yes	Yes	1, 4
Pampas cat, *O. colocolo*	Yes	Yes	Yes	No	1, 2, 4
Geoffroy's cat, *O. geoffroyi*	Yes	Yes	Yes	No	1, 6, 7
Kodkod, *O. guigna*	Yes	Yes		No	5
Manul, *O. manul*	Yes	Yes	Yes	No	1, 2
Leopard cat, *P. bengalensis*	Yes	Yes	Yes	Yes	1
Flat-headed cat, *P. planiceps*	Yes	No	No	No	1, 8
Rusty-spotted cat, *P. rubignosus*	Yes	Yes	Yes	No	2
Fishing cat, *P. viverrinus*	Yes	Yes	Yes	Maybe	1, 2
African golden cat, *P. aurata*	Yes	Yes	No	No	1, 9
Puma, *P. concolor*[3]	Yes	Yes	Yes	Maybe	1
Clouded leopard, *N. nebulosa*	Yes	Yes	Yes	Maybe	1
Lion, *P. leo*	Yes	Yes	Yes	Yes	1
Jaguar, *P. onca*	Yes	Yes	Yes	Yes	1
Leopard, *P. pardus*	Yes	Yes	Yes	Yes	1
Tiger, *P. tigris*	Yes	Yes	Yes	Yes	1
Marbled cat, *P. marmorata*	Yes	No	Yes	No	1, 10
Snow leopard, *U. uncia*	Yes	Yes	Yes	Yes	1

[1] Includes only institutions reporting to ISIS and/or monitored by the International Zoo Yearbook, with the exception of the newly established Iberian lynx breeding center, Doñana National Park, Spain.

[2] Sustainability assessed at species level according to total population size (± 50) and our best information or guesstimate on number of original founders.

[3] Generics only, no breeding program (A. Shoemaker *in litt.* 1993).

References

1. Seager and Demorest 1978; 2. Mellen 1993; 3. Sausman 1989; 4. Olney and Ellis 1991; 5. P. Quillen, pers. comm.; 6. ISIS Mammal Abstract 1991; 7. Anderson 1977; 8. Schaffer and Rosenthal 1984; 9. Tonkin and Kohler 1978; 10. Barnes 1976; 11. J. Mellen, pers. comm.; 12. M. Aymerich, pers. comm.; 13. Olbricht and Schürer 1993.

Source: Jill Mellen, Co-chair, Felid Taxon Advisory Group, American Zoo and Aquarium Association

Table 6
Structure of an AZA Species Survival Plan (SSP) Master Plan

I. Introduction

A. Introductory comments

B. Outline of objectives

1. Overall goal (e.g., retain 90% of genetic diversity for 200 years)
2. Number of founders desired, available, and presently in population
3. Carrying capacity
4. Generation time management
5. Management strategy (e.g., by mean kinship)
6. Lifetime offspring goals (number of offspring needed per individual founder and non-founder)
7. Population control methods
8. *In situ* recommendations
9. Others
    a. Special medical considerations
    b. Identification system for SSP animals
    c. Policy for breeding recommendations
    d. Special research goals
    e. Surplus animal policy

Genetic Analysis

A. Introduction

1. Introductory comments (i.e., special considerations)
2. List of parameters and assumptions used in analysis
3. Overview of results of analysis

B. List of mean kinship coefficients

C. List of inbreeding coefficients

D. Gene drop output (i.e., model of rate of genetic drift)

E. N_e estimations

Demographic Analysis

A. Introduction

1. Introductory comments (i.e., special considerations)
2. List of parameters and assumptions used in analysis
3. Population summary
    a. Population numbers
    b. Recent/Historical growth or decline
    c. Generation time
    d. Age of first reproduction and senescence

B. Life table (includes lambda, T, r, etc.)

C. Age pyramid

Recommendations

A. Institution by institution (sorted by institution)

1. Breedings for next few years
2. Transfers for next few years
3. Surplus
4. Animals to be held in non-breeding situation

B. Animal by animal (sorted by studbook number)

1. Breedings for next few years
2. Transfers for next few years
3. Surplus
4. Animals to be held in non-breeding situation

C. Other (e.g., research and medical)

Appendices

A. Tables

B. Graphs and figures

C. Other information

Table 7
Captive Breeding Programs and Studbooks for Felid Species

North America: Species Survival Plan (SSP)

Cheetah, *A. jubatus* (1984)
Clouded leopard, *N. nebulosa* (1989)
Asiatic lion, *P. leo persica* (1981)
Amur (*P.t. altaica*) + Sumatran (*P.t. sumatrae*) tigers (1992); Indochinese tiger (*P.t. corbetti*) under development; Generic tigers
Snow leopard, *U. uncia* (1983)

Europe and Russia: European Endangered Species Programme (EEP)

Cheetah, *A. jubatus*
Clouded leopard, *N. nebulosa*
Amur (*P.p. orientalis*) + Persian (*P.p. saxicolor*) leopards
Amur (*P.t. tigris*) + Sumatran (*P.t. sumatrae*) tigers
Snow leopard, *U. uncia*

British Isles: Joint Management of Species Group (JMSG)

Cheetah, *A. jubatus*
Margay, *L. wiedi*
Ocelot, *L. pardalis*
Geoffroy's cat, *O. geoffroyi*
Clouded leopard, *N. nebulosa*
Asiatic lion, *P. leo persica*
Persian leopard, (*P.p. saxicolor*) (1988)
Amur (*P.t. altaica*) and Sumatran (*P.t. sumatrae*) tigers
Snow leopard, *U. uncia*

Indonesia: Indonesian Species Programme (PKSBI)

Sumatran tiger (*P.t. tigris*)

Australasia: Australasian Species Management Programme (ASMP)

Asiatic golden cat, *C. temmincki* (1993)
Persian leopard (*P.p. saxicolor*)—may be dropped in favor of Javan leopard (*P.p. melas*) (1993)
Sumatran tiger (*P.t. sumatrae*) (1992)

Japan: Species Survival Committee of Japan (SSCJ)

Cheetah, *A. jubatus*
Amur tiger, *P. tigris altaica*
Snow leopard, *U. uncia*

Studbooks (I=International; R=Regional)

Cheetah, *A. jubatus:* I—1982; R (Great Britain)—1992
Sand cat, *F. margarita:* I—1988, but unofficial since late 1970s
Black-footed cat, *F. nigripes:* I—1988; R (North America)—under development
Ocelot, *L. pardalis:* R (North America)—under development
Margay, *L. wiedi:* R (Great Britain)
Geoffroy's cat, *O. geoffroyi:* R (Great Britain)

Continued on next page

Rusty-spotted cat, *P. rubiginosus:* I—under development
Fishing cat, *P. viverrinus:* R (North America) and I—1993
Clouded leopard, *N. nebulosa:* I—1980; R (Europe, India)
African lion, *P. leo:* I—1992
Asiatic lion, *P. leo persica:* I—1982 (suspended—see species account);
Jaguar, *P. onca:* R (North America)—under development; unofficial studbook publ. 1988
Asian leopard subspecies: North Chinese (*P.p. japonensis*), Sri Lankan (*P.p. kotiya*), Amur (*P.p. orientalis*) and Persian (*P.p. saxicolor*): I—1977; R (Europe, Great Britain, Australasia: *P.p. saxicolor*)
Amur tiger, *P.t. altaica:* I—1976
Sumatran tiger, *P.t. sumatrae:* I—1978; R (N. America)—1990; R (Indonesia) under development
Bengal tiger, *P.t. tigris:* I—1979; R (India)—under development
South China tiger, *P.t. amoyensis:* I—1983
Indochinese tiger, *P.t. corbetti:* I—1990
Snow leopard, *U. uncia:* I—1977

tiatives include technical assistance from experts in developed countries to zoos in developing countries in enclosure design and husbandry, animal selection (of known origin, previously held by other zoos or by private owners) for breeding programs, veterinary care and genetic analysis. In exchange for their assistance, western zoos would acquire access to new founders for breeding programs, and new material for genetic research (Quillen 1992; W. Johnson, S. O'Brien, P. Quillen, W. Swanson, pers. comm. 1993).

Captive Breeding and Population Management Programs

The first stage in the development of inter-institutional breeding programs began in 1966, when international studbooks were organized under the aegis of the International Union of Directors of Zoological Gardens (IUDZG) to trace the history of all individuals of rare species or subspecies in captivity (Dathe 1980). These registers are indispensable for tracking the degree of relatedness between animals. Studbooks for selected tiger subspecies (Seifert and Muller 1976), snow leopards (Blomqvist 1978), and selected leopard subspecies (Shoemaker 1981) were the first established within the cat family. However, the studbook system essentially left it up to individual zoos to take the initiative to act upon the demographic information contained in the registers and establish breeding consortia for the purposes of animal exchange and managed breeding.

The establishment of more structured breeding programs was urged at the first international conference on Breeding Endangered Species in Captivity, held in the U.K. in May 1972 (Smith 1972). At that time, the focus was on building up captive populations to avoid the need to remove more individuals from the wild. Concerns about preservation of genetic diversity and wild-adapted behavioral traits did not become a major issue until the second conference, held in July 1976 (Tudge 1976, Leyhausen 1977), and interest has grown exponentially since then.

Captive breeding and population management programs became institutionalized when the American Zoo and Aquarium Association (AZA) launched its Species Survival Plan (SSP) program in 1981. Under this program, zoos cooperate to manage individual animals within a number of zoo populations as a single population. The master plan includes demographic and genetic analyses of the population, based on studbook data, and makes recommendations for each animal in the population, including which ones should breed and with whom; which ones should not breed; which ones should be removed from the population; and which ones should be used for research, reintroduction, or genome banking (R. Wiese *in litt.* 1993). The outline of a SSP master plan is presented in Table 6.

Such programs allow for the ultimate in hands-on management, population manipulation to a degree that would be impossible to duplicate in the wild. Other regions have now established similar programs, and the species being so managed are shown in Table 7.

A Global Captive Action Plan for Felids

A Global Captive Action Plan (GCAP) for Felids (Wildt *et al.* 1992a) was produced in 1991-1992 during two consecutive annual workshops held by the AZA's Felid Taxon Advisory Group (TAG). The Felid TAG holds annual workshops to review progress and revise the Plan as necessary. The GCAP prioritizes species by region for the establishment of viable captive populations according to rarity in the wild. The Felid TAG workshops have attempted to quantify *in situ* rarity by applying the Mace-Lande criteria (Mace and Lande 1991) to 259 subspecies. The GCAP's priority ranking appears in Table 8, with each

Table 8
A Global Captive Action Plan for Felids (Wildt *et al.* 1992a)

Global Captive Action Plan Ranking (1 = highest priority)	Cat Action Plan Regional Vulnerability Ranking[1]
Africa	
1. Cheetah, *A. jubatus*	N=1(A); S=2(A)
2. Black-footed cat, *F. nigripes*	1
3. Lion, *P. leo*	2(A)
4. African golden cat, *P. aurata*	1
5. Serval, *L. serval*	N=2(A); S=3
6. African wildcat, *F.s. lybica group*	S=5
7. Caracal, *C. caracal*	S=4; N=Sa (A)
Asia	
1. Tiger subspecies: *altaica, amoyensis, corbetti, sumatrae*	1(A)
Iriomote cat, *P. [b.] iriomotensis*	no ranking, but high priority
2. Asiatic lion, *P. leo persica*	1
3. Flat-headed cat, *P. planiceps*	2
Bornean bay cat, *C. badia*	1
Marbled cat, *P. marmorata*	2
Snow leopard, *U. uncia*	1(A)
Clouded leopard, *N. nebulosa*	2(A)
Bengal tiger, *P.t. tigris*	1(A)
4. Manul, *O. manul*	3
5. Asiatic golden cat, *C. temmincki*	2
6. Chinese mountain cat, *F. bieti*	1
7. Persian leopard, *P.p. saxicolor*	3(A)
8. Amur leopard, *P.p. orientalis*	3(A)
9. Sri Lankan leopard, *P.p. kotiya*	3(A)
10. Asiatic wildcat, *F.s. ornata* group	As=2
11. North Chinese leopard, *P.p. japonensis*	3(A)
12. Southwest Asian wildcat subspecies	N=5b
Europe	
1. Iberian lynx, *L. pardinus*	1
2. Scottish wildcat, *F.s. grampia*	Er=3
3. European wildcat, *F.s silvestris* group	3
4. Eurasian lynx, *L. lynx*	Er=2; As=3
North America	
1. Florida panther, *P.c. coryi*	4(A)
2. Texas ocelot, *L.p. albescens*	4
3. North American puma subspecies	4(A)
Canada lynx, *L. canadensis*	3
Bobcat, *L. rufus*	4
4. Central American puma subspecies	4(A)
Latin America	
1. Andean mountain cat, *O. jacobitus*	1
2. Kodkod, *O. guigna*	1
3. Oncilla, *L. tigrinus*	2
4. Margay, *L. wiedi*	3
5. Pampas cat, *O. colocolo*	4

Continued on next page

Global Captive Action Plan Ranking (1 = highest priority)	**Cat Action Plan Regional Vulnerability Ranking[1]**
6. Texas jaguarundi, *H.y. cacomitli*	5
7. Ocelot, *L. pardalis*	4
8. Jaguar, *P. onca*	2(A)
9. Geoffroy's cat, *O. geoffroyi*	3
10. Jaguarundi, *H. yaguarondi*	5
Not included in the GCAP	
Jungle cat, *F. chaus*	T=4; N=5a
Sand cat, *F. margarita*	4
Leopard cat, *P. bengalensis*	5
Rusty-spotted cat, *P. rubiginosus*	2
Fishing cat, *P. viverrinus*	2

[1] As explained under Taxonomy, this Action Plan generally avoids reference to subspecies, given the questionable validity of traditional subspecific designations and the absence of modern taxonomic investigation of subspeciation for most cats. The regional vulnerability rankings used in this Action Plan do not necessarily correspond to the subspecific classification used for the GCAP.

As=Asia sub-region
Er=Europe sub-region
N=North Africa and Southwest Asia
S=Sub-Saharan Africa
T=Tropical Asia

species' vulnerability ranking given for comparison. Although global in scope, the priorities currently tend to reflect the North American membership of the Felid TAG, in that North American and European species are given relatively high profile, while Eurasian, tropical Asian and southwest Asian species are lumped together. However, the GCAP is expected to change as new information on the status of species in the wild becomes available—for example, upon publication of this Action Plan.

The Global Captive Action Plan is based solely on the premise that captive breeding programs should be established first for those taxa which are rarest or most threatened in the wild (Seal *et al.* 1993). It is recognized as an idealized strategy that does not take practical difficulties into account, such as the fact that founder captive populations of most rare small cats are very low or non-existent. The GCAP is meant to serve as a guideline for implementation plans, including Regional Collection Plans (RCPs) and Global Animal Survival Plans (GASPs—discussed below). The AZA created the TAG groups for the purpose of drawing up RCPs at the family level; British, European and Australasian zoos have also recently created TAGs for felids or carnivores (CBSG 1993). Tables 9 and 10 present the North American and Australasian RCPs, which establish regional priorities not only according to the GCAP, but also according to practical considerations, including captive space limitations within the region, number of known-origin captive animals, need for taxonomic study at the specific or sub-specific level, presence or absence of founder stock, and the existence of other captive breeding programs outside the region. Therefore, they look quite different from the GCAP list of priorities, and include recommendations for reducing populations of certain species while others are expanded.

While the GCAP considers multiple taxa, a Global Animal Survival Plan (GASP) is concerned with just one taxon, typically a species. A GASP sets out a strategy to coordinate the activities of regional captive breeding programs. Within the family Felidae, a GASP has been produced only for the tiger (Tilson *et al.* 1992). The goals of the Tiger GASP are shown in Table 11, and it is clear that the objective is to integrate *ex situ* and *in situ* conservation efforts for the tiger to a greater extent than any felid captive breeding program has attempted before.

Table 9
North American 1993-1994 Regional Collection Plan for Felids
(J. Mellen and D.E. Wildt *in litt.* 1993) (not in order of priority)

***L. canadensis, L. rufus, P. concolor*[1]**
Recommend no breeding; reduce total population to a target level of no more than 30 animals to be held for educational and research purposes only; assess SPARKS[2] database for population parameters[3].

L. serval
Recommend no breeding; reduce total population to a target level of no more than 30 animals to be held for educational and research purposes only; recommend propagating animals of known subspecies only.

C. caracal
Develop an international studbook for Asian subspecies and a regional studbook for African subspecies; reduce total population to a target level of 50 African animals to be held for educational and research purposes only; establish an Asian population of 25 pairs to eventually replace African animals; recommend propagating animals of known subspecies only.

P. rubiginosus
Acquire founders; establish and expand population to 25 pairs.

F. nigripes
Establish regional studbook and eventually an SSP; establish and expand population to 25 pairs.

L. tigrinus
Encourage an international studbook; establish and expand population to 25 pairs.

O. manul
Acquire additional founders; develop husbandry and propagation protocols; expand population to 25 pairs.

P. viverrinus
International studbook in place; acquire founders; establish and expand population to 25 pairs.

F. margarita
International studbook in place; expand population to 25 pairs.

L. pardalis
Establish a regional studbook; recommend propagating animals of known subspecies only; acquire new founders; establish and expand population to 25 pairs; maintain and expand relationship with the Texas ocelot recovery program (Feline Research Center, Texas A&I Univ.) and support a captive breeding program for this subspecies (if necessary).

P. leo
Combine Asiatic and African lions under one SSP; recommend breeding for those animals of known origin only.

P. onca
Recommend no breeding pending studbook review; identify studbook keeper.

P. pardus
Recommend no breeding of generics; see International Studbook on Rare Leopards for potential breeding stock.

A. jubatus, N. nebulosa, P. tigris, U. uncia
SSP in place.

C. temmincki, F. chaus, F. silvestris, H. yaguarondi, L. wiedi, O. colocolo, O. geoffroyi, P. bengalensis, P. planiceps, P. aurata, P. marmorata
Not currently recommended for breeding or maintenance in North American institutions.

[1] Except Florida panther.
[2] SPARKS is a software system developed by ISIS to synthesize data from ISIS studbook-like reports.
[3] Population parameters include size of population, age structure, number of institutions holding these animals, among others.

Table 10
Australasian 1993-1994 Regional Collection Plan for Felids
(Christie 1993) (not in order of priority)

L. pardalis
Replace with high priority SE Asian small carnivore.

C. temmincki
Continue SMP*, expand holdings.

A. jubatus, P. tigris sumatrae
Continue SMP.

N. nebulosa, P. leo persica
Acquire and develop SMP.

P. pardus saxicolor
Under review, develop SMP

***P. pardus melas* (Java)**
Under review.

P. leo, U. uncia
Maintain.

C. caracal schmitzii* (Turkmenistan), *P. viverrinus
Maintain two pair.

C. caracal, L. serval, L. lynx, L. rufus, P. bengalensis, P. concolor, P. pardus
Remove from active management and phase out holdings.

*Species Management Plan

Table 11
Goals of the Tiger Global Animal Survival Plan
(Tilson *et al.* 1992)

- To develop captive programs for tiger conservation with the paramount purpose of contributing to the survival and recovery of all distinct taxa in the wild.
- To contribute to tiger conservation by:
  - Developing, maintaining, and using captive breeding programs to provide a genetic and demographic reserve to re-establish or revitalize wild populations when the need and opportunity occurs;
  - Conducting problem-oriented research that will contribute to management of tigers in both captivity and the wild; collaborating on such research where appropriate with field researchers; communicating and transferring the results of such research to managers of other captive and wild populations;
  - Providing where possible financial as well as technical support for *in situ* Adopt-A-Park programs;
  - Using the tiger as a focus for conservation education, public relations, and marketing programs.

Advances in Assisted Reproduction

During the last decade, there has been growing interest in applying assisted reproductive technology, largely developed for domestic livestock, to wild animals. In the broadest terms, the technology includes artificial insemination, *in vitro* fertilization, embryo transfer, and gamete/embryo cryopreservation. While natural breeding of compatible pairs and maternal rearing of offspring are the preferred method of captive reproduction, and more effort needs to be directed toward appropriate husbandry and behavioral enrichment to ensure that this takes place, artificial propagation is a useful tool that also has potential application toward maintaining the viability of *in situ* populations.

To be successful, assisted reproductive techniques rely upon detailed understanding of fundamental reproductive events, a considerable list including the following: seasonal or genetic impacts on reproduction, duration of the estrus cycle, timing of ovulation, ejaculate norms, temporal patterns in gamete transport, implantation, gestation, parturition, postpartum fertility, and age at first and last reproduction. Fortunately, there are excellent baseline data available from years of study into the reproductive biology of the domestic cat (Wildt 1991a). Success with assisted reproduction in the domestic cat (Goodrowe *et al.* 1988, Howard *et al.* 1992) also provides model data which can potentially short-cut similar experimentation in other species (Wildt *et al.* 1986b). However, some reproductive parameters can differ quite sharply even between closely related species (Wildt *et al.* 1988, Brown *et al.* 1993), but with captive breeding programs as the catalyst, a substantial database is gradually being built up about the reproductive biology of different species (Wildt 1992b, Wildt *et al.* 1993a).

Of key importance is accurate information on the endocrine status of the female. Fresh or thawed sperm must be deposited coincident with ovulation, and embryos must be placed into the recipient at a time when the uterus is synchronous with the stage of embryo development. An ability to trace endocrine patterns also provides the opportunity to diagnose pregnancy and predict parturition. The standard method of endocrine monitoring involves regularly measuring hormone levels in blood, which may be practical for captive animals, but not for wild animals: anesthesia or immobilization stress can affect hormone levels. Recent attempts to detect hormonal metabolites non-invasively in animal wastes, both urine and feces, offer hope for development of a monitoring regime suitable to field conditions (Wildt 1991b, Brown 1992).

However, the use of assisted reproductive technology for wild populations lies well in the future. The techniques will first have to be perfected in captivity, and their regular application will be most immediately useful to improving the efficiency and effectiveness of captive breeding programs. These programs have run into problems when two animals recommended for breeding turn out to be incompatible. In such cases, it would be simpler to use assisted reproduction than to attempt to manipulate an array of environmental factors to stimulate natural copulation. It will also be less dangerous, more cost-effective and more practical to transport frozen spermatozoa and/or embryos between zoological institutions than stress-susceptible live animals (Wildt 1992a, Ballou 1992, IUDZG/CBSG 1993).

In relation to other taxa, there has been a relatively large amount of research aimed specifically at refining assisted reproduction techniques for captive felids. Artificial insemination has been used to produce living young in the leopard cat, cheetah, tiger, puma and clouded leopard (Howard *et al.* 1992a, Wildt 1992b, Donaghue *et al.* 1993). A litter of leopard cats has been produced using sperm collected and frozen at one institution and inseminated into a female at another institution (J. Howard and D. Wildt unpubl. data). All of these successes have relied upon the use of exogenous hormones to stimulate ovarian activity, followed by surgical laparoscopic deposition of sperm directly into the uterine lumen. Vaginal or intracervical insemination in felids (other than the domestic cat) has worked only once: a leopard cub was produced by this method and carried to full term, although it was stillborn (Dresser *et al.* 1982). The problem appears to be related to anesthesia, which relaxes the uterus and reduces the contractions which normally assist in sperm transport (Wildt 1991c, Howard *et al.* 1992b).

Through *in vitro* fertilization (IVF), embryos have been produced for several felid species, including the domestic cat, Asiatic wildcat, jungle cat, African golden cat, fishing cat, tiger, puma, snow leopard and cheetah (Goodrowe *et al.* 1988, Donaghue *et al.* 1990, Miller *et al.* 1990, Pope and Dresser 1991, Pope *et al.* 1989, 1993). The transfer of these embryos into surrogate females has resulted in living young in the domestic cat (Goodrowe *et al.* 1988), Asiatic wildcat, and tiger. Bengal tiger cubs, conceived as IVF embryos, were born to a Siberian tiger dam after embryo transfer (Donoghue *et al.* 1990). The Asiatic wildcat kittens were produced in a domestic cat female (Pope *et al.* 1989). While this has been described as interspecific transfer, the wildcat is very closely related to the domestic cat and is considered conspecific here. The exciting aspect of interspecies embryo transfer is that "rare" females could be hormonally stimulated to produce many eggs, which could be fertilized *in vitro* and transferred to "common" female surrogates (Wildt 1991c). However, there is growing evidence that biological compatibility between the trophoblast (progenitor of the placenta) of the embryo and the uterine endometrium is a very complex and restrictive phenomenon, and interspecies embryo transfer is unlikely to become routine (Wildt 1991b). Also, IVF using frozen-thawed embryos has only been successful with domestic cats (Dresser *et al.* 1988).

Finally, interest is growing in the establishment of genetic resource banks to hold frozen gametes, embryos, blood products, tissue, and DNA collected from a large number of species. Wildt (1992a) has envisioned genetic resource banks as functioning much like a large financial institution, with constant "withdrawals" and "deposits" performed by many branches and between continents. As assisted reproductive technology advances, the advantages of moving genes via germ plasm rather than living animals are obvious in terms of time, money, simplicity, and safety. Improved access to biological samples taken from wild animals will also help to increase fundamental knowledge of species biology by providing more opportunity for the participation of laboratory scientists in conservation research (Wildt 1992a).

The tiger is the subject of the first Genome Resource Banking Action Plan (Wildt *et al.* 1993b). The plan, drawn up for the North American region, identifies key captive animals for sperm, tissue, and blood collection, and recommends collection of germ plasm from wild animals in cooperation with field scientists. It represents the first organized effort to sample, evaluate, cryopreserve, catalog, maintain and use wildlife germ plasm. The managers state that the "resource of frozen tiger semen (and eventually embryos) will be used interactively with living populations to periodically infuse genetic material among diverse captive or wild stocks or preserved genes from previous generations" (Wildt *et al.* 1993b: 1).

Linking *Ex situ* and *In situ* Cat Conservation

There is a strong movement in the zoo community toward becoming more closely involved with wildlife conservation (Anon. 1974, IUDZG/CBSG 1993). The contribution made by the IUCN/SSC Conservation Breeding Specialist Group (CBSG) through their Population and Habitat Viability Analysis (PHVA) workshops—discussed in Chapter 3—has been particularly significant. The general public, particularly in the developed countries, is becoming more aware of the need to conserve wildlife and, as zoos compete for people's leisure time with a growing number of other options, it is likely that zoos will increasingly seek to demonstrate their commitment to conservation. Four areas where zoos have the potential to make significant contributions are reviewed.

Maintaining Viable Captive Populations of Rare Species

Captive breeding is a primary area of zoo expertise, and the maintenance of genetically viable populations of rare and endangered species has been a major emphasis since the early 1980s (Seal and Foose 1986, Hutchins and Wiese 1991, IUDZG/CBSG 1993). In terms of species conservation, it is important to maintain viable populations of rare species in captivity for the following two purposes (IUCN 1987):

1. As an insurance population for possible reintroduction should the species become extinct in the wild or over part of its range;
2. As a source of new genetic material to infuse diversity into depleted wild populations.

The status of captive cat populations and their self-sustainability has been reviewed in this chapter. With the exception of the big cats, captive populations are biased toward more common species. The small cats are relatively poorly represented, particularly the rare Category 1-3 species, and most regional populations are not self-sustaining. This situation is unlikely to change until research into the status and ecology of these small cats, as recommended by this Action Plan, is carried out; it is inadvisable to remove individuals from wild populations of these species unless basic studies have been done. There may be more individuals of these species held in captivity, some in private collections, than are known at present (P. Quillen, pers. comm.).

The North American and Australasian Regional Collection Plans recommend that zoos reduce their holdings of the more common and easily reproduced species to free captive space for those that are less common but, for the near future, acquisition of new founders or unrelated animals depends upon international cooperation with reputable zoos in the range states. Years of work lie ahead before all of the rarer species of the family Felidae are maintained in viable captive populations.

The problems of reintroducing cats into the wild are discussed in Chapter 6, but can be summarized here by noting that, in general, it is not high on the list of priorities for cat conservation in the near future. For reintroduction, efforts should first be directed toward alleviating the pressures which drove the population to extinction in the first place. Otherwise, reintroduction is unlikely to be successful, and may harm the cause of species conservation rather than advance it.

In terms of restocking, or infusing genetic diversity, there are several major tasks which need to be accomplished before such action can be undertaken. First, small, isolated and endangered populations need to be identified systematically through greatly increased field survey efforts. Second, their demography and dynamics need to be understood so that appropriate candidate populations—and possibly even candidate individuals—can be selected. Third, it is an open question whether new, captive-reared animals can be introduced to existing wild populations and both survive and breed. Fourth, assisted reproductive techniques need to be further developed before they can be used effectively in the field.

The zoo community often predicts that wild populations will some day be as intensively managed as zoo populations (e.g., Tilson 1992b), but this will happen only if it is accepted as inevitable that cat populations of the future will be confined to small, isolated protected areas, so that numbers are too low to conserve original genetic diversity. Without active and strengthened effort to conserve cats on private lands, or to maintain habitat corridors which restore connectivity to populations isolated by habitat change, this may indeed come to pass.

Of all the cats, the problem of too-small, isolated populations is most advanced for the tiger, and it is probably for this species that the resources of the zoo community will be called upon first. Plans to develop a genome resource bank for the tiger are timely (Wildt *et al.* 1993b). Tigers are well-represented and well-managed in captivity, and those responsible for their oversight are guided by an interactive strategic plan which has as its "paramount purpose... contributing to the survival and recovery of all distinct taxa in the wild," and recognizes that "captive populations are a support, not a substitute, for wild populations" (Tilson *et al.* 1992).

However, tigers are seriously threatened by commercial poaching, and it is of top priority to protect individual populations effectively and actively monitor their status. "Reinvigorating" these small populations can only take place when the poaching threat has been brought under control so that populations are relatively stable and their demography, dynamics, and genetics can be assessed.

Therefore, while it is important to maintain viable captive populations and continue to refine assisted reproduction in captive animals, neither is likely to be applied to wild cat conservation in the near future. In the meantime, zoos can contribute more immediately by increasing their role in the areas discussed below, most importantly public education and direct financial support.

Research

Zoos are increasingly looking to wild populations to help them better manage their captive populations, with the cheetah being a good example among the cats. Because of problems with poor reproduction and susceptibility to disease in captivity, the North American Cheetah Species Survival Plan (SSP) is studying wild behaviors to help design more appropriate captive habitat for cheetahs, and is collecting information on incidence of disease in wild populations (Caro 1993, Laurenson 1993; L. Marker-Kraus, L. Munson, pers. comm.).

Conversely, field biologists should increase cooperation with the zoo community to improve the conservation management of wild populations. For example, there is a wealth of knowledge among breeders about biological and reproductive parameters of cat species, which can provide baseline data to aid understanding of the dynamics of wild populations. For most cats, the data in the Species Accounts under the heading Biology is derived from captive animals, and is just an indication of the volume of physiological data which could be collected.

Zoo animals have provided the foundation for the development of classic descriptive biological sciences, including anatomy, morphology, taxonomy, classification, study of locomotion, nutrition, and other aspects of behavior. Captive studies, particularly the work of Leyhausen (1979), have greatly advanced understanding of cat behavior. Newer scientific disciplines also benefit from studies undertaken on captive animals, including small population biology, genetic and molecular studies, wildlife veterinary medicine, pathology, parasitology and bio-energetics (Hutchins *et al.* 1991, IUDZG/CBSG 1993, S. O'Brien pers. comm.). Of special importance to field biologists, methods of individual identification can be developed from and tested on captive animals (e.g., Miththapala *et al.* 1989).

Public Education

The World Zoo Conservation Strategy (IUDZG/CBSG 1993) estimates that the world's 1,100 organized zoos annually receive at least 600 million visitors, over 10 percent of the entire world population. Zoo visitors include people of all ages from a broad spectrum of social, ethnic, cultural and educational backgrounds, all of whom have one thing in common: an interest in animals. In addition to casual visitors, many formal education groups visit zoos, often consisting of children, but also including university

Zoos can promote public support for wildlife conservation with displays of animals.

and pre-university students.

The live animals exhibited by zoos can give meaning and immediacy to conservation education far beyond that achieved by film or print. Many zoos now have attractive settings for big cats, but much could be done to improve the displays of lesser cats to promote wider public interest.

The World Zoo Conservation Strategy emphasizes that conservation education is a key element in zoo education, which in its most basic form consists of information about the threatened status of an exhibited animal and an explanation of the causal factors. Animal exhibits, however, can be used to explain a variety of biological subjects, ranging from species-specific ecological and behavioral adaptations to broader themes such as ecological balance, evolutionary radiations and biological diversity. Creative exhibits and educational material at zoos are an invaluable resource for the cause of wildlife conservation, with enormous and still under-realized potential to stimulate in the general public an abiding interest in wildlife and concern for its preservation.

Wildlife conservation is of international importance, but depends on local action. The zoo forum is an appropriate one for educating people about various approaches to conservation around the world, and for helping to engender in the public a more sophisticated grasp of the issues involved. To this end, there should be greater cooperation between field conservationists and zoo educators. In view of the public's fascination with cats, it would be ideal for zoos to display educational material highlighting key projects and the work of organizations concerned with the conservation of wild cats. The Cat Specialist Group is well-positioned to play an advisory role in setting up such displays and exhibits. In this way, guidance would be provided to those visitors wanting to become more actively involved. This pertains especially to pre-university students; the importance of recruiting more field conservation specialists has been emphasized in Chapter 3.

Helping to Pay the Costs of Wildlife Conservation

Conservation benefits arising from zoo research and education of visitors are important, but are largely diffuse and indirect. Zoos seeking to play active roles in the field of wildlife conservation could become more directly involved by helping to fund high priority *in situ* conservation projects. As pointed out above, special exhibits can be created around these projects which can serve as a draw to visitors.

Traditionally, zoos have invested comparatively little in field conservation (Hutchins and Wiese 1991), although some, such as the Jersey Wildlife Trust, have been outstanding in their efforts. In addition, several large public zoos support semi-independent zoological societies which play a major role in wildlife conservation (e.g. the Frankfurt and New York Zoological Societies and the Zoological Society of London). Aside from the work of these organizations, we are aware of very few examples of zoo funding for field projects which specifically benefit cats.

The Tiger Global Animal Survival Plan (Tilson *et al.* 1992) recommends that participating zoos cooperate to provide $925,000 a year for 10 years to *in situ* tiger conservation, especially through "Adopt-A-Park" programs. The GASP points out that there are over 325 "hard currency" zoos with tigers, and the level of financial commitment sought represents an average of U.S. $2,770 per institution, or just over $1,000 per captive tiger.

It would be possible for individual zoos collectively to make a substantial contribution to wild cat conservation if a small annual donation were paid into a fund for the implementation of priority projects along the lines of those recommended by this Action Plan. By keeping the per animal donation low, smaller zoos would not be disproportionately burdened and it is likely that zoos would not find the request unreasonable. In return, zoos could expect to receive progress reports so that appropriate displays could be created around their involvement. Rather than have to work out cat conservation projects on an individual, ad hoc basis, zoos could legitimately publicize direct financial support for a number of projects involving various species.

Such a level of funding support from the zoos of the world is entirely appropriate —a "conservation duty"— and would not be so onerous as to rule out support for other projects. Until such time that interactive management of wild and captive populations becomes an effective and widely used tool, zoos could make a substantial, immediate and urgently needed contribution by increasing their direct support of conservation of wild cat populations (Action Plan Project 14).

Part II
Major Issues in Cat Conservation

Chapter 6
Reintroduction

Introduction

The Species Survival Commission of the IUCN includes the Reintroduction Specialist Group. The group has drafted guidelines for reintroduction projects, which are available from the SSC office at IUCN headquarters in Gland, Switzerland.

The umbrella term "reintroduction" includes several different concepts as defined below:

1. *Reintroduction:* in strict terms, an attempt to establish a species, subspecies, or race in an area which was once part of its historical range, but from which it has become extinct. Re-establishment is a synonym, but implies that reintroduction has been successful, something that may require considerable time to assess.

2. *Translocation:* movement of individuals or populations from one part of their range to another.

3. *Reinforcement/Supplementation:* addition of individuals to an existing population of the same species, subspecies, or race.

4. *Conservation/Benign introduction:* an attempt to establish a species, for the purpose of conservation, outside its recorded distribution, but within an appropriate habitat and eco-geographical area.

The following sections review recent felid reintroductions of these various types. In concluding, the lessons learned from these projects are assessed, and the role reintroduction has to play in wild cat conservation in the 1990s is evaluated.

Reintroductions

Several cat species have been reintroduced to parts of their range from which they had become extinct. All of these reintroductions have taken place in developed countries, or in those African countries with well-funded wildlife departments. Few projects, however, have been carefully planned and executed, although there are exceptions. Three examples of well-planned reintroductions are discussed below.

In Germany's state of Bavaria, 129 wild-caught and captive-bred European wildcats (75 males and 54 females) were released over a period of five years (1984-1989) at three sites in state-owned forest. Planning and collection of the animals to be reintroduced began several years prior to the releases. After the releases, the animals were monitored by radio-telemetry and by distribution of questionnaires to local residents, workers, and hikers. There was high road-kill in the first weeks following release, and survival was estimated preliminarily to be quite low, of the order of 20-30% (Büttner and Worel 1990). Still, there was evidence of reproduction at all three release sites.

In the Adirondack mountains of northern New York state, 83 Canada lynx (48 males and 35 females), wild-caught in the Canadian Yukon, were released over three winters from 1988-1990. Twenty-three lynxes had died by early 1992: 12 were hit by cars, five were accidentally shot, and six died from miscellaneous causes, including a young lynx killed by an adult male. Three lynx raided livestock pens. Some lynx migrated far from the release sites, but human-related mortality was low within New York state, due in part to substantial pre-release publicity and public education. While there is still no direct evidence of breeding, there have been unverified sightings of kittens (Brocke and Gustafson 1992).

In Georgia, 32 bobcats (15 males and 17 females), wild-caught on the coastal plain, were reintroduced in 1988-1989 to Cumberland Island, near the southern Georgia coast. The island is largely undeveloped, and prey densities were found to be high. All of the reintroduced bobcats were radio-collared; blood samples were taken prior to release; and the project received widespread publicity through the media. Several graduate students did thesis work around different aspects of the reintroduction, including feeding ecology and effects of reintroduced cats on prey populations (Baker 1991), population dynamics and evaluation of census methods (Diefenbach 1992), and social organization and habitat use (W. James in prep.). Most animals were recaptured for examination after the first year following release, and they were found to have increased their weight by an average of 12.3% (Diefenbach 1992). There was also evidence of breeding in the first year, with four dens and 10 kittens found (Baker 1991). Diefenbach (1992) estimated adult survival rate at 93% and juvenile (<1 year) survival at 35%. The population more than doubled following the first year of release, and reproduction apparently declined after three years as density increased.

Other reintroductions have been less carefully planned. These include servals, cheetahs, and lions in various South African reserves (van Aarde and Skinner 1986, Anderson 1992); wildcats and Eurasian lynx in several European countries (Breitenmoser and Breitenmoser-Würsten 1990, Stahl and Artois 1991); and pumas in several southern and western American states (Jordan 1991, Hornocker 1992). Most of these efforts involved the release of fewer than 20 animals, and in some cases fewer than five. Only the release of lynx in Switzerland has involved rigorous follow-up monitoring. Although monitoring only began 10 years after the releases, it has continued for 10 years and is now the longest running follow-up radiotelemetry study of a reintroduced cat population.

How successful were these reintroductions? It depends upon the time frame used to measure success. Many reintroduced cat populations are surviving today, and some, like the bobcats of Cumberland Island or Eurasian lynx reintroduced to Slovenia, have rapidly increased in number and—in the case of Slovenia—have considerably expanded their range (Cop 1992). However, long-term persistence of any of the populations cannot be assured. Small populations are vulnerable to severe fluctuations caused by environmental or demographic factors. Diefenbach (1992) developed population viability models for the Cumberland Island bobcats and, based solely on demographic factors, estimated the median persistence time of the population at only 65 years. The island (only 80 km^2 in size) may be too small to support a viable bobcat population, even with supplemental releases to minimize inbreeding.

In a review of the wildcat reintroduction in Bavaria, Stahl and Artois (1991) commented that even with a project of that scope, which had existed for 10 years, there was no guarantee that viable wildcat populations had become established in any of the release sites. They added that greater care was needed before launching major reintroduction programs. They suggested that the risks of hybridization with domestic cats and the high degree of threat resulting from habitat modification meant that reintroduction schemes could not be regarded as a priority strategy for conservation of the European wildcat. Attention should instead focus on conservation of existing populations.

An example of the sort of unpredictable demographic, environmental and genetic changes that can affect small reintroduced populations is a series of events which have befallen the lynx population reintroduced in Switzerland over 20 years ago. Mortality has been so high, primarily due to illegal killing and road deaths, that the radiation and growth of the population has stopped. In the Jura Mountains sub-population, all but one resident male have been killed. That male has expanded his home range to cover the home ranges of six females, thereby disproportionately increasing his genetic representation in the population. The lack of other competing breeding males is related to poor cub survival. Observations and estimates showed that a maximum of 3-6 of 22 young in the Jura reached their third year, and all of them were female (Breitenmoser *et al.* 1994).

Another example is the lion population of the Hluhluwe/Umfolozi reserve complex in South Africa. A nomadic male took up residence in the park in 1958, and seven years later two adult females and two young cubs were released. The population today is thus descended from a very small gene pool: the two females came from the same pride, and it is presumed that they were related, while the original cubs were likely to have been killed by the male (Anderson 1981, 1992). In 1993, male lions from the reserve were found to have very low sperm quality (M. Briggs *in litt.* 1993).

Successful reintroduction relies upon careful planning and preparation, which requires both time and money. If this is not to be wasted, it is in the interest of management authorities to monitor reintroduced populations for at least several decades following release, and to be prepared to take active measures if necessary to prevent reextinction.

Another problem which will affect reintroductions where cats have been absent for long periods is the impact of predators on inexperienced prey populations, both wild and domestic. When released in Switzerland, lynx had been extinct for at least 100 years, and reintroduced animals killed considerable numbers of roe deer and chamois (Breitenmoser and Haller 1993). Reintroduced lynx also killed domesticated sheep. From 1984-1988, 135 attacks were reported in an area of France adjoining the Swiss Jura, and in 1989, 426 attacks were reported within an area of only 50 km^2 (Herrenschmidt and Vandel 1989, Anon. 1990d). Breitenmoser (1983) found that sheep made up 20% of lynx kills. Livestock depredation in France and Switzerland arouses considerable controversy and public antagonism despite compensation schemes. Similarly, cheetahs released in several southern African reserves had to be removed because of their high levels of predation on small populations of antelopes in fenced reserves which were not previously exposed to to large predators (Pettifer 1981, van Dyk 1991, Anderson 1992).

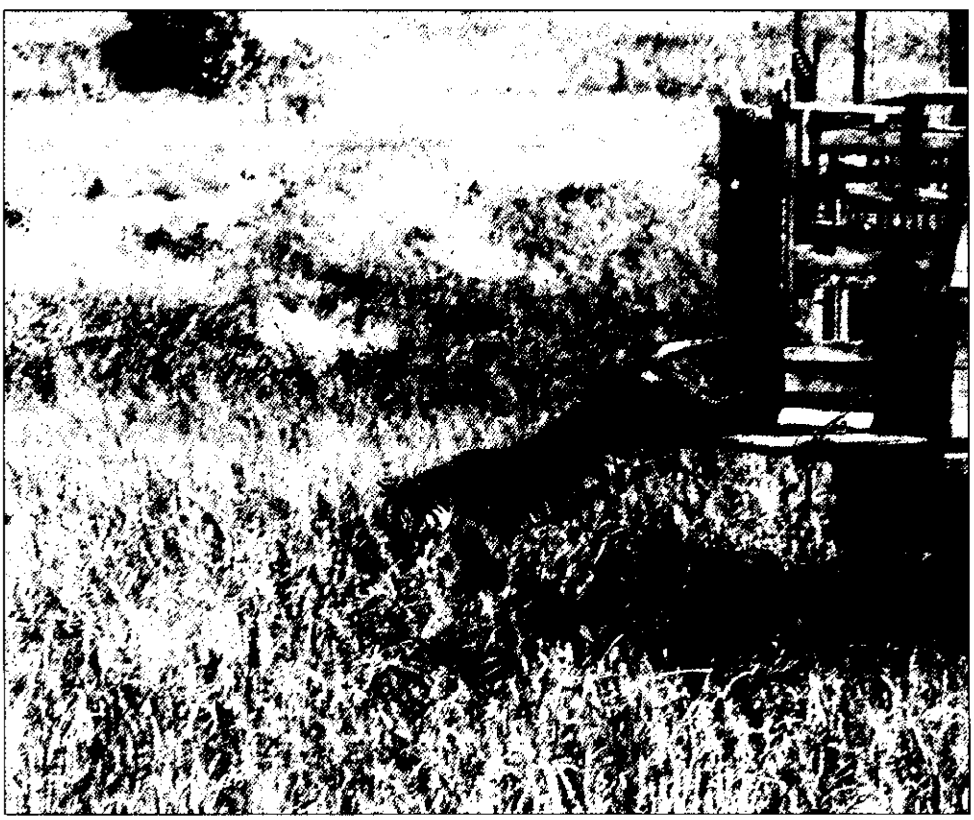
Cat reintroduction projects can expect predators to have a strong initial impact on prey populations. Although prey animals can regain their escape instincts fairly rapidly (Breitenmoser and Haller 1993), the consequences could be more serious inside small fenced areas, such as wildlife reserves.

Reintroduced wild-caught cats generally survive better than captive-bred animals. This is because animals reared in captivity have not developed foraging skills, and have little fear of humans. Captive-raised cheetahs in South Africa, for example, repeatedly raided the chicken houses of people living on the game farm where they were released, even in daylight with people sitting about (and throwing stones) (van Dyk 1991). However, it is possible to raise captive-bred animals so that prey-capture skills are learned. The Bavarian wildcat reintroduction project began with four wild-caught pairs. When they had bred, the mothers and young were kept in enclosures where live prey was released. After six months of age, the young cats were moved to acclimatization enclosures near the release site and fed. They were released shortly thereafter, with supplemental food supplies (Büttner and Worel 1990).

With proper care and precautions, captive animals can fare as well, if not better, than wild-caught cats. Captive-bred pumas released in Florida have not only survived and reproduced (Jordan 1991, 1994), but also appear to be settling down in the release area more readily than translocated wild-caught animals (Belden and McCown 1993). Even with wild-caught animals, it is recommended that they be kept in large enclosures near the release site for a short period, to allow them to recover from capture and transport stress, eat, and become acclimatized, rather than releasing them directly into the wild (Diefenbach 1992).

Translocations and Population Supplementation

Although translocation and population supplementation are often described as conservation tools of the future, which will permit intensive genetic management of small isolated cat populations, experimentation has actually been underway for decades. These efforts have been local and informal, and thus documentation is lacking. Documentation is most readily accessible for translocations of big cats in eastern and southern Africa but, as with most rein-



Peter Jackson

Translocated tiger being released in Khao Yai National Park, Thailand, in 1988. It had been taking livestock at the edge of the park.

Lewis Horwitz

Tranquilized lions being transported by air from Etosha in Namibia for reintroduction in the Pilanesberg National Park, Bophuthatswana.

troductions, few of these attempts have been very systematic, and none have involved long-term monitoring.

Lions, leopards, and cheetahs, typically problem animals, have been translocated and introduced into reserves where populations were considered to be low. As an example of more deliberate attempts to increase population size, cheetahs were released into South Africa's Kruger and Kalahari Gemsbok National Parks, and into Namibia's Etosha National Park, in the 1970s (du Preez 1970, Anderson 1992). Although some of the animals were marked with ear tags, few were subsequently resighted, and resighting effort was not systematic, so that the effects, both immediate and long term, of population supplementation are unknown.

Translocation has often failed, and there are no guidelines for ensuring the success of a translocation attempt. Some animals establish residence at the release site, and others migrate long distances. The behavior does not appear to be species-specific—it may be highly individualized, or depend upon conditions at the release site. As an example of a successful translocation/population supplementation, the two lionesses introduced into Hluhluwe/Umfolozi in South Africa (where there was only one resident male at the time) were translocated from Kruger National Park, more than 100 km away. They were the founders of a population now estimated at 100 animals (Anderson 1981, 1992). However, in some cases cats have moved far away from their release sites (Hamilton 1981), even if there were no resident animals present to drive them off (Gossow and Honsig-Erlenburg 1986, Jordan 1991). One translocated leopard in South Africa travelled more than 540 km back to his original home range area (Jewell 1982).

The importance of better understanding of the complexities of injecting an "outsider" into an existing felid society is illustrated by an attempt to translocate a tiger which killed a woman at the edge of the Indian Sundarbans mangrove delta. It was released in the interior of the Sundarbans Tiger Reserve, but was killed by another, larger tiger only 20 meters from the transfer cage, to which it had been seen to return a short time before (Seidensticker *et al.* 1976). In a second translocation in the Sundarbans, a tiger which had taken livestock was released elsewhere, swam a creek, and disappeared immediately amongst the mangroves (Ghosh 1988). Its ultimate fate is unknown.

While knowledge of the results of translocations and supplementations remains generally obscure and localized, there are a few well-publicized, even notorious, examples. These translocations were carried out for the welfare of individual animals, rather than strictly in the interest of population conservation. Captive-raised animals were "returned to freedom in the wild" by release in parks holding resident populations. Examples include the release of lions, leopards, and a cheetah by Joy and George Adamson (Adamson 1960,1969,1986), and the release of a tigress and two leopards in India's Dudhwa National Park by Arjan Singh (1981,1984). These projects were marred by injuries and deaths to humans, probably due to the cats' familiarity with people and lack of natural caution.

In the Indian case, an outbreak of tiger attacks on people soon after Singh's tigress, Tara, went wild in 1978 led to public accusations that she was responsible, a cry taken up by politicians and used to attack the cause of wildlife conservation. Leading Indian tiger specialists, however, believe that the attacks on people, which continued into 1993, were an unfortunate coincidence, and that Tara had probably been killed by a resident tiger. Singh (1981), on the other hand, is convinced that Tara was integrated into the local tiger population and subsequently bred. The affair is an illustration of the political perils of reintroductions.

One of the main scientific concerns involved in translocation and population supplementation is that introduced animals should not introduce "foreign" genes into the resident population. A feature of the Adamson and Singh releases, and of a later release of lions from Kenya into Botswana (Anon. 1991a, b, 1993c) was that the animals were not of the local race and, moreover, that some were genetic "cocktails" due to cross-breeding with other subspecies or generics in captivity. Wirth (1990) quotes the late Sir Peter Scott (then chairman of the IUCN Species Survival Commission) expressing concern that the tigress released by Singh was a hybrid of two races, neither of them the same as the Dudhwa population. Scott added that if she bred it would "make a further genetic cocktail, and from a scientific and conservationist point of view this would be deplorable."

However, while the issue is obviously important, clear-cut guidelines will be slow to emerge. How significant were genetic or adaptive differences between, for example, the Kenya lions and the resident Botswana lions? There was no attempt to evaluate this before release. However, preliminary genetic and morphological analysis of African leopards indicates that all these leopards, despite the very different habitats (sand desert, tropical rain forest) in which they are found, could be considered to belong to a single subspecies (Miththapala 1992). Can the same be said for lions? Analysis of the mitochondrial DNA of several populations of east African antelope species revealed great interspecific variation in the amount of genetic differentiation between populations (P. Kat *in litt.* 1993).

Furthermore, in some cases the introduction of new genetic material may be desirable. O'Brien *et al.* (1990) compared the genetics of two isolated populations of Florida panther. One population had been supplemented (not officially) by the release of hybrid North and South American pumas, some of which had bred so that their genes entered the population's gene pool. The genetic diversity of this population was substantially greater than that of the isolated pure population, leading to the conclusion that hybridization can be beneficial for small inbred populations (CBSG 1991).

Another aspect of population supplementation which needs further examination before it can be recommended as a conservation tool is how introduced animals are accepted by the resident population. Under what circumstances can introduced cats be expected to establish a territory and be incorporated into the breeding population? Under what circumstances are immigrants likely to be killed? Are the chances of success higher with females than with males? These questions should all be investigated before population supplementation is seriously considered as a high-tech solution to the genetic problems faced by small wild populations.

In the planning of any felid translocations or reintroductions, the risk of accidental transmission of disease into unaffected populations via released animals must be carefully assessed. Woodford and Rossiter (1993) recommend that veterinary involvement in reintroduction projects should begin as early as possible. They point out instances of inadequate disease risk assessment resulting in expensive failures, and the introduction of destructive pathogens into resident wildlife populations by captive-bred and wild-caught animals. Infectious diseases may have short or long-term effects on population size and viability by affecting rates and patterns of mortality or reproduction.

The assessment procedure should address all the infectious agents to which the animals to be moved might have been exposed, and could carry, and which might affect conspecifics or other species at the destination. In this context the list of diseases to be considered may be longer than that in Table 5 in the chapter on Research.

For some infections, tests are available, which, if negative, provide confidence that the animal is not a carrier. For others (e.g., tuberculosis), testing may not be straightforward or reliable, or there may be no test available (e.g., spongiform encephalopathy). It should be borne in mind that several diseases of felines (e.g., feline immunodeficiency virus disease and feline spongiform encephalopathy) have been recognized only very recently and it is not unlikely that other, as yet unrecognized, infections may occur in cats.

The details of the appropriate protocols for quarantine and testing procedures to be undertaken prior to shipment or release will depend upon the species involved and knowledge of the infectious disease status of the donor and recipient populations, and of other species with which they are in contact via a food chain or other routes.

Predatory training (of captive animals), genetic selection, disease screening and quarantine, immobilization, transportation, and release add up to considerable expense, which will be wasted if introduced animals fail to survive and breed. It is unfortunate that the results of introducing new animals were not more closely monitored in previous attempts, but there is likely to be opportunity in the future, as translocation remains an important management tool on a local scale. For instance, when faced with limited options regarding how to handle a rare big cat which is causing problems with people and livestock, translocation is often considered an attractive alternative to elimination (see Chapter 2).

Because these issues are likely to take on greater importance to cat conservation in the next century, it is not argued here that experimentation with translocation and population supplementation cease, only that they be more carefully undertaken and monitored.

Summary of Problems with Reintroducing Cats

This review, in addition to those of others (Wemmer and Sunquist 1988, Diefenbach 1992, Yalden 1993), points to a set of key considerations which should be undertaken before reintroduction of cats, especially the big cats, is contemplated seriously.

Release Areas Acceptable to People

For reintroduction, "wilderness" areas with low human population density are probably ideal, but such areas are now few and far between (see Chapter 1). Human persecution is a major cause of cat extirpation, and if cats are to be reintroduced to settled areas, substantial pre-release publicity and communication should be undertaken. Reintroduced cats may roam a great distance from the release area, enter settled areas, and kill livestock or people. As pointed out by Moore (1992), because carnivores are widely viewed as "villains" threatening livestock and people, the most important factors in the survival of reintroduced carnivores are often socio-political.

Release Areas with Adequate and Suitable Food Supply

Prior to reintroduction, prey species in the release area should be censused, and their numbers evaluated to see roughly how many cats they are capable of sustaining. Predation rates can be calculated from studies of kill rate in the wild, or from maintenance energy rates in captivity, coupled with what is known of the species ecology—e.g., females with young have higher energy requirements, and while most cats will utilize nearly all of a large kill, remaining near the carcass until it is substantially consumed, cheetahs require fresh meat and may kill large animals more frequently than, say, leopards. Estimation of prey base adequacy may be complicated if predators have been absent from the area for several generations. Under such circumstances, prey numbers may not only be higher than under the original predator-present ecological dynamic, but may also experience sharp immediate declines due to prey inexperience with predators.

For supplementation of depleted cat populations, managers should ensure that prey decline was not among the factors leading to the decline of the cats.

Source of Animals to be Reintroduced

As Yalden (1993) pointed out, there is general agreement that reintroduced animals should be taxonomically and genetically as close as possible to the former population, yet an objective definition of "suitability" has not yet been developed, and cannot realistically be expected to emerge for some time. There needs to be substantially more research on intraspecific diversity before good general guidelines can be formulated. For the present, according to local priorities and sensibilities, it is up to local managers to weigh the ecological significance of an ecosystem having (a) no cats where they formerly existed or (b) cats of potentially different genetic makeup than those that formerly existed.

The same consideration applies to introducing animals of potentially different genetic makeup to resident, albeit severely reduced, populations. The draft guidelines of the IUCN Reintroduction Specialist Group advise against it. However, managers may some day face a real dilemma: is it better to let a population go extinct, or become highly inbred, rather than "contaminate" it?

These questions highlight the importance of linking field studies and genetic/morphological analysis to shed more light on the significance of ecological adaptation and genetic diversity within cat species. Answers to these questions are likely to be species-specific, and will require substantial research and field collection effort to obtain.

Disease Risks

Precautions are essential against introduction of disease to wild populations by reintroduced animals. Assessment of all the infectious agents to which animals to be reintroduced have been exposed should be carried out and quarantine requirements respected. The advice of the IUCN/SSC Veterinary Specialist Group should be sought.

Costs of Reintroduction

Reintroduction can be very expensive, especially if captive animals are involved which have to receive acclimatization and predatory training. For example, an ambitious plan has been developed to breed wild-caught Florida panthers in captivity for eventual population supplementation. The plan estimates costs of building a captive facility, developing reproductive technology, and genetic analysis at over U.S. $500,000 (Seal *et al.* 1989). Wemmer and Sunquist (1988) estimate the capital cost of constructing a snow leopard propagation and holding facility in a snow leopard range state at over $200,000, with annual maintenance costs of nearly $20,000.

Even if wild-caught animals are used, costs of publicity and communication, capture, interim feeding and maintenance, animal evaluation (clinical examination, blood samples), equipment (telemetry, vehicles) and follow-up monitoring (personnel support) can be cumulatively high. It is also very important that project budgets take the costs of long-term future monitoring into account, particularly if initial project expenses are high.

Peter Jackson

Development of a reintroduced lynx population is being studied in the Swiss Jura Mountains.

Conclusions: What is the Role of Reintroduction in Cat Conservation?

If highest priority for reintroduction were to go to those species which have disappeared from substantial portions of their former range, the list for cats would include the following: lion, tiger, leopard, and cheetah (north Africa and parts of Asia); jaguar (southern U.S. and north-central Argentina); and puma (eastern North America). But direct human persecution and depletion of the prey base were the major causes of decline. In the case of the north African and southwest Asian cats, antelope populations, which would provide prey, are still in a seriously depleted condition (East 1992a, b), and it is unlikely that local people are ready to support reintroduction. It is also questionable whether the current stock of captive animals is genetically representative of extinct populations or, if they are not, whether they are suitable substitutes. In the case of the jaguar, the northern and southern parts of its former range are now heavily settled, and hardly present ideal conditions for reintroduction. Only in the case of the eastern cougar are conditions suitable for a widespread reintroduction effort (particularly in northeastern North America), and then the sporadic sightings of wild animals (indicating that there are perhaps survivors) and the lack of authentic eastern cougars in captivity are stumbling blocks.

In short, for the 1990s at least, it is unlikely that reintroduction will play a role which is significant on a global scale, even for those cats which need it most. However, work which pertains to the reintroduction of these cats should continue. For example, the puma reintroduction in northern Florida and translocations elsewhere in the United States (see Species Account) should continue to be monitored and lessons drawn. The ecology of jaguars living near settled areas, and management solutions to minimize livestock depredation, should continue to be studied. For the north African and southwest Asian cats, the Iranian, Egyptian, and Algerian cheetahs (the best stock for future reintroductions elsewhere in the region) should be protected and their ecology studied.

Reintroduction of Asiatic lions to a site in the former range continues to be under active consideration because of their current existence as a single, isolated, high-density and low genetic diversity population in an Indian reserve. Johnsingh *et al.* (1991), Ravi Chellam and Johnsingh (1993b), and Walker (1994) favor the establishment of a second population (see Species Account). However, the socio-political aspects need careful consideration, since people, including livestock owners, unused to the proximity of a large, potentially dangerous predator, will be living around, if not actually in, any reintroduction site in India.

However, on a regional or local scale, reintroduction, translocation and population supplementation can be very important tools. For example, although the viability of some of the populations is questionable, much of the western range of the European wildcat and Eurasian lynx was colonized in the last few decades by reintroduced animals (Breitenmoser and Breitenmoser-Würsten 1990, Stahl and Artois 1991). While these species are not globally endangered, their re-appearance in western Europe is of great regional significance. Similarly, while the reintroduction of Canada lynx to northeastern New York is not of great advantage to the survival of the species, it is important for the "Lower 48" United States, where lynx populations are small, threatened, and widely separated.

All parties interested in reintroducing cats are urged to contact both the Cat and the Reintroduction Specialist Groups. The considerations enumerated above should be taken into account before any animals are actually released. Monitoring of recently reintroduced populations should continue, and future research should evaluate the aspects of predator reintroduction which remain in question, including:

1. The conditions under which translocation of individuals to resident populations is successful;
2. How predatory training of captive-raised animals can most efficiently be accomplished;
3. How animals differ genetically and morphologically in different parts of their ranges, and;
4. How people can be encouraged to tolerate or even facilitate the return of a potentially dangerous or destructive felid predator.

The final point needs to be stressed because of the impact carnivores can have on human communities, which are almost always involved. The comments of Jo Gipps of the Zoological Society of London in a preface to a symposium on reintroductions (Gipps 1991) are especially relevant as far as big cats are concerned: "However good our understanding of the biology of a species and its habitat, conservation projects are almost inevitably doomed to failure unless the dynamics of the human relationships are well understood by everyone involved, and unless those relationships are based on mutual respect and understanding of each other's problems."

Part III
An Action Plan for Cat Conservation in the 1990s

Introduction

The following projects are priorities for wild cat conservation over the coming decade. They are presented in a simple summary form. The projects focus on the most vulnerable species, and are organized into two sections. Section 1 consists of general projects which address major issues in cat conservation, as defined in Part II of this document. The second, larger group of projects is laid out in the same order as the Species Accounts. To locate projects for certain species or regions, see the list of projects which follows. Although these projects are numerous, they do not address all species, nor all the general recommendations made for future cat work in Part II.

There are two types of projects included in the Action Plan. The first type consists of existing projects which have received varying amounts of their budgeted funding. For these projects, a contact address is provided for donors and other interested parties. They are distinguished from the second group by the placement of an asterisk * after the title.

The second type of project consists of those proposed by Cat Specialist Group members. These projects need funding and, in many cases, workers. Donors and other interested parties should contact the Cat Specialist Group directly for details. The Chairman maintains a database of telephone, fax, and e-mail contacts for the executors of existing projects, and asks that the Group be informed of contacts related to these projects.

The Cat Specialist Group's contact addresses are: Peter Jackson, Chairman, IUCN/SSC Cat Specialist Group, 1172 Bougy, Switzerland, Tel/Fax +41 21 808 6012, e-mail peterjackson@gn.apc.org or c/o Species Survival Commission, IUCN—The World Conservation Union, 1196 Gland, Switzerland. Tel: +41 (22) 999 0001, e-mail: mgd@hq.iucn.ch; Kristin Nowell, 2520-4, 41st St. NW, Washington DC 20007, U.S.A.

Projects are categorized as follows in terms of approximate annual budget (all figures in 1994 U.S. $):

I	$10,000 or less
II	$10,000—$20,000
III	$20,000—$50,000
IV	$50,000—$100,000
V	over $100,000

* = Ongoing Project

List of Priority Projects

I. General Topics

Implementation of the Cat Action Plan

1. Establishment of the Cat Conservation Data Center

Habitat loss and fragmentation

2. Response of a felid community to logging of tropical Asian rain forest
3. Acquisition of map databases for overlay of cat distribution survey data
4. Identification of potential protected areas for conservation of biodiversity in the Indian Himalayas*

Management of big cats near people

5. Global survey of methods and techniques to minimize the impact of livestock losses to cats
6. Support for the National Center for Research, Management, and Conservation of Predators in Brazil*

Research

7. A guide to census procedures for cat populations
8. A workshop to define minimum viable population sizes for cat species
9. A fund for field collection and processing of biological samples for genetic, morphological, and clinical analysis

10. Systematics of the genus *Felis* and hybridization problems*
11. A survey of disease in wild cat populations*

Trade

12. Understanding the market for tiger bone medicines*
13. The leopard cat in China: ecology and management for sustainable utilization*

Cats in Captivity

14. Establish a zoo-based fund for field conservation of wild cats
15. Evaluation of subspeciation and establishment of regional captive breeding programs for the wildcat*

Reintroduction

16. Long-term monitoring of the reintroduced Eurasian lynx population in Switzerland*
17. Population dynamics of a reintroduced bobcat population in a small isolated habitat block*

II. Species Projects

Sub-Saharan Africa

Black-footed cat (Category 1)

18. Natural history of the black-footed cat*
19. Distribution of the black-footed cat

African golden cat (Category 1)

20. Natural history of the African golden cat*
21. Distribution of the African golden cat

Cheetah (Category 2A)

22. Support for the Cheetah Conservation Fund*
23. Factors limiting cheetah populations outside protected areas*
24. Support for the Serengeti Cheetah Project*
25. African cheetah status survey*
26. Distribution, status, and captive breeding of the cheetah in Zimbabwe*
27. Cheetah census and disease surveillance in Kenya*

Lion (Category 2A)

28. Pan-African lion survey*
29. Predator-prey relationship between lions and large ungulates in Kruger National Park*
30. Support for the Serengeti Lion Project*
31. Support for the N!aiuh Project in the Namibian Kalahari*
32. Resolving lion and livestock conflicts in west Africa

Serval (Category 3)

No specific projects suggested, but see related projects.

Leopard (Category 4A)

33. Evaluation of the effects of sport hunting on leopard population dynamics
34. Leopard ecology and density in tropical African rain forest*

Caracal (Category 4)

No specific projects suggested, but see related projects.

African wildcat (Category 5)

No specific projects suggested, but see related projects.

North Africa and Southwest Asia

Asiatic lion (Category 1)

35. Establishment of a second population of Asiatic lions in India*

Cheetah (Category 1A)

36. Conservation of the Asian cheetah in Iran
37. Natural history, genetics, and conservation status of the cheetah in the Saharan region

Serval (Category 2A)

38. Survey for the leopard and the serval in the Atlas Mountains of Morocco*

Leopard (Category 3A)

39. Distribution and conservation status of the leopard in north Africa and southwest Asia*
40. Support for the Arabian Leopard Trust*

Sand cat (Category 4)

41. Distribution of the sand cat

See also related project under manul.

Caracal (Category 4A)

42. Natural history, distribution, and status of the caracal in India*

Jungle cat (Category 5)

No specific projects suggested, but see related projects.

Wildcat (Category 5)

43. Natural history, status, and captive breeding of the wildcat in Israel*

Tropical Asia

Tiger (Category 1A)

44. Protection of the Amur tiger and its habitat in the Russian Far East*
45. Behavior and ecology of the Amur tiger*
46. Conservation of the South China tiger*
47. Support for Global Tiger Patrol*
48. Improving the reliability of tiger censuses in India*
49. Distribution, abundance, and ecological and conservation status of the tiger in India*
50. Conservation of viable tiger populations in India: the effects of population isolation and movement corridors
51. Support for the Ranthambhore Foundation's eco-development Project*
52. Support for the Tigerhaven Wildlife Trust*
53. Current distribution of tiger populations in east and southeast Asia*
54. Support for the Chitwan Tiger Project*
55. Development of a tiger population simulation model*
56. Genetic evaluation of subspeciation in the tiger*

Bornean bay cat (Category 1)

57. Natural history, distribution, and status of the Bornean bay cat*

Clouded leopard (Category 2A)

58. Natural history of the clouded leopard*
59. Distribution of the clouded leopard and other sympatric small cats*

Asiatic golden cat (Category 2)

60. Natural history of the Asiatic golden cat

See also clouded leopard project.

Flat-headed cat (Category 2)

61. Natural history of the flat-headed cat
62. Distribution of the flat-headed cat

Rusty-spotted cat (Category 2)

63. Natural history and distribution of the rusty-spotted cat

Fishing cat (Category 2)

64. Natural history of the fishing cat*
65. Distribution of the fishing cat

Marbled cat (Category 2)

66. Natural history of the marbled cat

See also related project under clouded leopard.

Leopard (Category 3A)

67. Support for the Far Eastern Leopard Fund*
68. Leopard ecology in three habitats in India*

Jungle cat (Category 4)

No specific projects suggested, but see related projects.

Leopard cat (Category 5)

See project under Trade.

Iriomote cat (no ranking)

69. Evaluation of the taxonomic status of the Iriomote cat*
70. Conservation of the Iriomote cat*

Eurasia

Asia sub-region

Snow leopard (Category 1A)

71. Support for the International Snow Leopard Trust*
72. Status and management of the snow leopard in Tibet*
73. Evaluation of the status of the snow leopard in Russia and the central Asian republics*
74. Reducing livestock depredation in the Annapurna Conservation Area of Nepal: implementation of a snow leopard management plan*
75. Conservation of snow leopards and their habitat in northern Pakistan*

Chinese mountain cat (Category 1)

76. Natural history, distribution, and status of the Chinese mountain cat

Manul (Category 2)

77. Natural history of the manul

78. Status of the cheetah, sand cat, and manul in Baluchistan

79. Status of the manul in the area of the Caspian Sea

Asiatic wildcat (Category 2)
No specific projects suggested, but see related projects.

Eurasian lynx (Category 3)
80. Status survey for the lynx and other small cats in Xinjiang province, China*

Europe sub-region

Iberian lynx (Category 1)
81. Implementation of conservation management measures for the Iberian lynx*

82. Applied studies on the conservation of the Iberian lynx*

83. Increasing public awareness of the endangered status of the Iberian lynx in Spain*

Eurasian lynx (Category 2)
84. Support for the Status and Conservation of the Alpine Lynx Population Project*

85. Spatial organization, population dynamics, and feeding ecology of the reintroduced lynx population in Slovenia*

86. Preliminary assessment of lynx status in the Caucasus region*

87. Biology and ecology of the lynx in the lowland primeval forest of the Bialowieza Nature Reserve, Poland

88. Ecology and status of lynx populations in Scandinavia*

European wildcat (Category 3)
89. Status survey and taxonomic evaluation of the wildcats of the Mediterranean islands*

90. Status and distribution of the wildcat in France*

See also related projects.

The Americas

Kodkod (Category 1)
91. Natural history, distribution, and status of the kodkod*

Andean mountain cat (Category 1)
92. Natural history, distribution, and status of the Andean mountain cat

Jaguar (Category 2A)
93. Jaguar and puma depredation of livestock in the Pantanal of Mato Grosso, Brazil*

94. Ecology of jaguars and other carnivores in the Brazilian cerrado*

95. Conservation of the jaguar in Mexican tropical dry forest*

See also related project under Management of Big Cats Near People.

Oncilla (Category 3)
96. Natural history of the oncilla, margay, and ocelot

97. Distribution of the oncilla

Margay (Category 3)
See related projects above.

Canada lynx (Category 3)
98. Long-term studies of the effects of harvest on Canada lynx populations*

Geoffroy's cat (Category 3)
99. Natural history and distribution of the Geoffroy's cat and pampas cat in Argentinian pampas grasslands

Puma (Category 4A)
100. Support for investigations into the presence of pumas in eastern North America*

101. Support for Proyecto Puma in Chilean Patagonia*

102. Projeto Puma: conservation of the puma in southern Brazil*

103. Long-term study of puma ecology in southwestern Alberta, Canada*

See also related project under Management of Big Cats Near People.

Ocelot (Category 4)
See projects under oncilla.

Bobcat (Category 4)
104. Distribution and status of the bobcat and puma in the Mexican Sierras

Pampas cat (Category 4)
105. Evaluation of the taxonomic status of the pampas cat*

See also related project under Geoffroy's cat.

Jaguarundi (Category 5)
No specific projects suggested, but see related projects.

Priority Projects for Cat Conservation in the 1990s

I. General Topics

Implementation of the Cat Action Plan

1. Establishment of the Cat Conservation Data Center

Objective: To assist implementation of the Cat Action Plan by establishing a base from which the Cat Specialist Group can collect and distribute current conservation-related data on wild cats. This will facilitate communication between potential donors of funds and project executants; communication of project results to relevant parties elsewhere; and the dissemination of information on cat conservation for the purposes of public education and awareness.

Description: The Cat Specialist Group will establish a permanent center to serve as a coordinating office and clearing-house for data relevant to cats and their conservation. The center will be central to ensuring that the successes achieved by priority projects can be duplicated elsewhere, and mistakes avoided. Through cooperation with the Group's research librarian, Gail Foreman, the center will respond to all requests for papers, contacts, information, or other assistance, with priority going to activities directly related to Action Plan Projects. Another priority for the center will be to coordinate with regional officers the conduct of surveys to improve mapping of cat populations and databases on species occurrence in protected areas. Finally, the center will greatly increase communication and information exchange between people involved in cat conservation by continuing to produce the biannual Specialist Group newsletter, *Cat News*, and by circulating copies of papers and reports.

Annual budget: III

Time frame: Ongoing

Habitat Loss and Fragmentation

2. Response of a felid community to logging of tropical Asian rain forest

Objectives: To evaluate the responses of a felid guild in previously undisturbed habitat to selective logging; and to develop recommendations to minimize negative impacts of logging on these species.

Description: This is a pilot project related to conservation of all rain-forest cats. The timber industry is a major part of the economies of most countries with extensive tropical rain forest, and its effects on cat species have not been systematically investigated. Tropical Asian rain forest is the most species-rich in terms of cats, and home to several which rank high in vulnerability to extinction. This study will also lead to increased understanding of how rain forest cats coexist.

A team of investigators will study the ecology of a group of sympatric rain forest cat species for 1-2 years in an area scheduled to be logged prior to commencement of logging activity. Study animals will continue to be monitored throughout the logging process, and for several years following its completion.

There are three candidate study regions: Sumatra (tiger, clouded leopard, marbled cat, flat-headed cat, Asiatic golden cat, fishing cat, leopard cat); Borneo (clouded leopard, Bornean bay cat, flat-headed cat, marbled cat, leopard cat); continental southeast Asia (tiger, leopard, clouded leopard, Asiatic golden cat, marbled cat, flat-headed cat, fishing cat, leopard cat). It would be useful to conduct at least two separate studies for comparative purposes.

Annual budget: IV-V

Time frame: 5-7 years

3. Acquisition of map databases for overlay of cat distribution survey data

Objectives: To improve map-based cat conservation action planning by: (1) evaluation of population fragmentation; (2) identification of important habitat corridors; (3) evaluation of the geographic distribution of inter- and intraspecific diversity; and (4) prioritization of populations for conservation action.

Description: The Cat Conservation Data Center will acquire Geographic Information System (GIS) map databases, which will be overlaid with field survey data on cat species presence/absence and population estimates. Map overlays include habitat, wilderness, population, settlement and development, protected areas, altitude, precipitation, etc. The map systems will be a great advantage for strategic planning of surveys, field studies, and conservation action. This project coincides with the plans of the IUCN Species Survival Commission and the World Conservation Monitoring Centre to build up a global species database, including maps, based on data provided by SSC Specialist Groups.

Annual budget: I-II

Time frame: Ongoing

4. Identification of potential protected areas for conservation of biodiversity in the Indian Himalayas*

Objectives: (1) Using targeted field surveys, Geographic Information System (GIS) and satellite imagery, to build a model that assesses the general features of high altitude biodiversity, including the habitat requirements of key species such as the snow leopard and its prey and; (2) to apply the model to potential reserve sites in the two major biogeographic regions of the Indian Himalayas.

Description: Among the more pressing ecological problems facing India's natural resources is the establishment of new parks and reserves in the Himalayas—the least protected biogeographic region in India, and its richest region in terms of cat species. Over the next 10 years, the government of India wishes to create a protected area network across the Indian Himalayas, doubling the area coverage. Unfortunately, this region is among the most remote and difficult in the world to work in. New methods are needed that capitalize on limited time in the field for surveys. This study will develop and test new methods built around targeted field surveys and augmented by satellite remote sensing and GIS. Species' habitat requirements and field survey data will drive spatial models on biodiversity. The project will attempt to locate key habitat features from satellite imagery and satellite-derived elevation models. The model will be developed with survey data from existing reserves, and then tested in potentially suitable areas. If the model performs well, the methodology should be applicable throughout the mountains of central Asia. This approach will illuminate the potential of using models and remote sensing to (1) evaluate cat species distribution and status and (2) improve biodiversity conservation through more strategic planning of protected area network coverage.

Annual budget: V

Time frame: 6 years

Contact: Hemendra Panwar, Director, Wildlife Institute of India, P.O. Box 18, Chandrabani, Dehra Dun 249 001, Uttar Pradesh, India. Don Hunter, National Biological Survey, Midcontinent Ecological Science Center, 4512 McMurry Ave., Fort Collins, CO 80525-3400, U.S.A.

Management of Big Cats Near People

5. Global survey of methods and techniques to minimize the impact of livestock losses to cats

Objectives: To document a global sample of methods used to minimize the impact of livestock losses to cats; and to disseminate this information as widely as possible.

Description: Although persecution of big cats because of predation on livestock is a major cause of their extirpation outside protected areas, there has been no comprehensive survey of management methods used to control the problem. A global survey of methods to minimize depredation, sampling a variety of countries, habitats, and species, would be a useful information source to management authorities and land owners trying to develop appropriate solutions to their own depredation problems.

A specialist, working closely with the Cat Specialist Group, will undertake a global literature review and telephone/mail survey of methods used to minimize livestock loss to big cats. The survey will be organized according to representative regional forms of livestock husbandry. A report will be published in three languages (English, French, and Spanish), and distributed through the Cat Specialist Group and other appropriate channels.

Annual budget: III

Time frame: 1-2 years

6. Support for the National Center for Research, Management, and Conservation of Predators in Brazil*

Objective: To support a national center of expertise on predators in Brazil, particularly the big cats, with priority focus on resolving human/carnivore conflicts.

Description: This is a pilot project relevant to resolving human/carnivore conflicts in Latin America. Brazil holds the largest populations of jaguar and puma in the New World. Cattle ranching is a major industry, and thus this country is an appropriate place to test various management solutions to the problems of livestock predation by big cats in tropical America.

Under the auspices of the Brazilian governmental Instituto Brasileiro de Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA), a National Center for Research, Management and Conservation of Predators in Brazil has been established under the direction of an expert in big cat ecology. The Center will coordinate and act as a catalyst for field studies, reintroduction and translocation projects, education programs, fund raising, compensation schemes, and country-wide data collection on carnivores.

Annual budget: IV

Time frame: Ongoing

Contact: Peter Crawshaw, IBAMA, Parque Nacional do Iguaçu, C.P. 750, Foz do Iguaçu, Paraná 85851-970, Brazil.

Research

7. A guide to census procedures for cat populations

Objective: To select, refine, and recommend standardized census procedures for different cat species and habitat types.

Description: Cats are notoriously difficult to census, and estimating density, either in absolute or relative terms, is important for assessing the status of cat populations. The Cat Specialist Group will work with experts in the field of counting animals, who will be given the opportunity to visit various field projects and communicate with members regarding problems with censusing cat species in various habitat types. Guidelines will be produced to inform field scientists about the strengths and weaknesses of various census techniques for cats, and to recommend which technique is most appropriate for different cat species, habitat types, and field conditions.

Annual budget: IV

Time frame: 2-3 years

8. A workshop to define minimum viable population size for cat species

Objectives: To hold a Cat Specialist Group workshop to define minimum viable population (MVP) size for well-studied cats; and to evaluate species status in terms of population distribution and protected area coverage.

Description: A major conservation issue for large cat species is that isolated reserves may not be of sufficient size to harbor minimum viable populations. Although the theory behind MVP is well-developed, it has not yet been applied in a useful way to the ecology and distribution of cats. Cat conservation could be much more strategic if (1) the MVP concept were evaluated in the specific light of current knowledge of cat biology and social organization; (2) species- and habitat- specific definitions of MVP size were developed; and (3) the current population distribution and protected area coverage were evaluated for each species in terms of conservation of MVPs.

A team of cat specialists will conduct a workshop to discuss the concept of MVP in relation to big cats, and to define MVP size for the better-studied species (including tiger, snow leopard, cheetah, lion, jaguar, leopard, and puma). Workshop participants will also evaluate species status based on MVP definitions by reviewing information on population distribution and protected area coverage.

Annual budget: V

Time frame: 1 year

9. A fund for field collection and processing of biological samples for genetic, morphological, and clinical analysis

Objective: To establish a Cat Specialist Group Fund in order to increase field collection and processing of biological samples for genetic, morphological, and clinical analysis.

Description: As described in the Research chapter, knowledge of inter- and intraspecific diversity, population dynamics, and the ecological role of disease would be greatly enhanced by collection of more biological samples from across species ranges. Appendix 2 sets out a protocol for field collection of such samples. Processing and shipping can be prohibitively costly for small projects and for individuals, and under such circumstances these costs will be supported by a small Cat Specialist Group Fund.

Annual budget: I

Time frame: Ongoing

10. Systematics of the genus *Felis* and hybridization problems*

Objectives: To revise the systematics of cats of the genus *Felis;* and to investigate the present and historical incidence of hybridization between these cats and the domestic cat.

Description: Hybridization occurs widely between domestic cats and wildcats, but the extent of the problem is not known for other close relatives included in the genus *Felis*. This museum-based study will examine the problem through morphological, geographical, and temporal variation in the skins and skulls of *Felis* species. This examination will also help define subspeciation in these cats, with taxonomic evaluation of the wildcat, the widest ranging cat species, of particular importance. In addition, a model will be developed to simulate the effects of hybridization with domestic cats on the genetic integrity of wild populations. This project will be complementary to Projects 15 and 43.

Annual budget: III

Time frame: 3 years

Contact: Andrew Kitchener, Royal Museum of Scotland, Chambers St., Edinburgh EH1 1JF, U.K.

11. A survey of disease in wild cat populations*

Objectives: To gather and exchange published and unpublished information on the prevalence and impact of disease, particularly viruses, on cat populations, particularly those which are small and isolated; to create a surveillance network; and to prepare action plans with the help of computer modelling.

Description: The Laboratory for Studies of Rabies and Wild Animal Pathology, sponsored in part by the French government, and working closely with the Cat and Veterinary Specialist Groups, is carrying out a literature review and mail survey regarding the incidence of disease in wild cat populations. In most cases, the laboratory can offer free analysis and diagnostic services to field researchers. It will aid publication of findings through SSC newsletters and specialized meetings. A computer model of the effects of disease in isolated populations of carnivores is being developed. The funds will be used to support graduate student thesis work and increase the center's ability to process samples.

Annual budget: I

Time frame: Ongoing

Contact: Marc Artois, CNEVA—Laboratoire d'Etudes sur la Rage et la Pathologie des Animaux Sauvages, BP 9, 54220 Malzeville, France.

Trade

12. Understanding the market for tiger bone medicines*

Objectives: To evaluate the effectiveness of trade bans on the markets for tiger bone medicines in China, Taiwan, South Korea, and major overseas Asian communities; and make further recommendations to bring illegal trade under effective control.

Description: Commercial poaching for tiger bone is the prevailing threat to the survival of the species, yet there is little available information on the market for tiger bone medicines. Most major producer and consumer nations had banned trade in tiger bone medicines by 1993, but illegal trade continues. Very little is known about consumer demand for tiger bone, and there have been no serious attempts to address it in terms of public education campaigns or provision of substitutes. In order to halt commercial tiger poaching effectively, conservationists must understand the organization and dynamics of the tiger bone market.

This project will have three components. The first is a survey of manufactured medicines (made mainly in China and South Korea). Samples will be collected and analyzed by the U.S. Fish and Wildlife Service's Wildlife Forensics Laboratory for the presence of tiger bone. China and South Korea, the two major producing countries, recently banned manufacture of these medicines; the effects of this ban will be assessed. The second component is a survey of traditional pharmacies in major Asian and western cities for the availability of raw tiger bone and tiger bone medicines, authentic and fake. Information will be collected through interviews on sale volume and substitutes. Finally, consumers of tiger bone medicines will be surveyed, so that the nature of the demand can be evaluated, and appropriate measures formulated to address it. Recommendations will be made for bringing the market under effective control.

Annual budget: III

Time frame: 2 years

Contact: TRAFFIC International, 219c Huntingdon Road, Cambridge, CB3 0DL, U.K.

13. The leopard cat in China: ecology and management for sustainable utilization*

Objective: To collect and analyze the harvest, trade, and ecological data necessary to establish a sustainable management system for the leopard cat in China.

Description: The leopard cat is the only species in the current international fur trade which is exported mainly from a developing country. It has been the most heavily traded cat species over the late 1980s, with the vast majority of skins originating in southern China. The biological impact of the harvest is unknown but believed to be significant, and the Chinese government wishes to implement a more effective management system.

The project, initiated in 1992 by the Chinese government with the support and approval of CITES, has two components. The first is an intensive survey of China's leopard cat harvest, regulatory management, and market organization at local, provincial and national levels. The second component gathers ecological data on the leopard cat in China through intensive comparative field studies of two populations: one protected and one harvested. The results of this study will be used to design a management system which ensures that future leopard cat harvests are sustainable.

Annual budget: III

Time frame: 4-5 years

Contact: Jinping Yu, Dept. of Zoology, 331 Funchess Hall, Auburn University, Alabama 31849-5414, U.S.A.

Cats in Captivity

14. Establishment of a zoo-based fund for field conservation of wild cats

Objective: To establish a fund for *in situ* cat conservation based on small annual donations from zoos holding cats in their collections.

Description: Zoos are increasingly committed to and involved with wildlife conservation. As discussed in Chapter 5, zoos can make an immediate and tangible contribution to cat conservation through increased support of field projects such as those proposed in this Action Plan. However, few zoos have the infrastructure, expertise, and budgetary flexibility to fund international field conservation projects directly. This project proposes that zoos holding cats make a small annual contribution to a Cat Specialist Group-linked fund for field projects, based on the total number of cats in their collections. In return, annual progress reports on field projects sponsored by the fund will be provided to contributing zoos, so that appropriate educational and promotional displays can be created.

Annual budget: I (for staff time to establish and administer the fund)

Time frame: Ongoing

15. Evaluation of subspeciation and establishment of regional captive breeding programs for the wildcat*

Objectives: To determine the degree of subspeciation in the wildcat *Felis silvestris* and to maintain viable populations of these subspecies in captivity.

Description: The wildcat has the largest range of all the cat species, and is probably differentiated into a number of subspecies or perhaps even separate species. Hybridization with domestic cats is taking place across most of this range. It is important to conserve viable populations of pure wildcat subspecies in captivity, while solutions to the problems of hybridization in the wild are worked out. Various institutions around the world maintain small wildcat populations; additional "pure" founders may need to be acquired. Captive breeding programs will be established on a regional basis to maintain genetic diversity. Zoos will participate in taxonomic analysis of the wildcat by providing animals and samples for study. This project will be complementary to Projects 10 and 43.

Annual budget: IV

Time frame: 5 years

Contact: IUCN/SSC Conservation Breeding Specialist Group, 12101 Johnny Cake Ridge Rd., Apple Valley, MN 55124, U.S.A. AZA Felid Taxon Advisory Group, Jill Mellen, Co-chair, Washington Park Zoo, 4001 S.W. Canyon Rd., Portland, OR 97221-2799, U.S.A.

Reintroduction

16. Long-term monitoring of the reintroduced Eurasian lynx population in Switzerland*

Objectives: To continue to monitor the process of population establishment of lynx in Switzerland.

Description: This is the longest-running study of the process of population establishment in a felid reintroduction. Its results are highly relevant to understanding the factors (biological, ecological, demographic, cultural, political) which affect reintroduction of large felid predators. It consists of two parts: (1) monitoring of the dynamics and status of the two separate reintroduced lynx populations (Alps and Jura Mountains), and (2) a field study of lynx ecology in the Jura Mountains. The monitoring program keeps track of the development of the total range occupied by the reintroduced populations, lynx killed or found dead, and damage to livestock caused by lynx. The complementary field study examines spatial and social structure, and recruitment and mortality rates. Special attention is given to possible congenital problems in the small Jura sub-population, which are suspected because of unusually high losses of male kittens.

Annual budget: IV

Time frame: Ongoing

Contact: Urs and Christine Breitenmoser and Simon Capt, Swiss Lynx Project, Villettengässli 4, CH-3074 Muri, Switzerland.

17. Population dynamics of a reintroduced bobcat population in a small, isolated habitat block*

Objectives: To continue monitoring the reintroduced bobcat population on Cumberland Island, Georgia (82 km^2), which is predicted by population viability models to have a high probability of extinction, in order to evaluate in detail the dynamics of a cat population confined to a small, isolated area of habitat.

Description: Most of the world's protected areas are less than 100 km^2 in size. It is predicted that many parks and reserves are too small to support viable populations of cats, but there is little empirical evidence of the processes that drive small populations to extinction in nature. The Cumberland Island Bobcat Project is a unique opportunity to study the phenomenon of population viability in the field from start to finish. The original population size, and its genetic makeup, are known, and the island is typical of the size of most of the world's protected areas, and presents a worst-case scenario in terms of isolation of many of the world's protected areas.

The reintroduction of bobcats to Cumberland Island was set up by the University of Georgia as a model project to study small populations. Blood samples were collected for genetic analysis from all of the founder animals. Population viability models have predicted a high chance of extinction within the next 100 years, and even population supplementation will theoretically do little to minimize chronic inbreeding. This is a rare chance to test the models empirically. The project, run by the University of Georgia, will continue to monitor population dynamics by conducting censuses and using radio-telemetry.

Annual budget: III

Time frame: Long-term (10+ years)

Contact: Robert Warren and Michael Conroy, Warnell School of Forest Resources, University of Georgia, Athens, GA 30602-2152, U.S.A.

See also Project 35 for the Asiatic lion.

II. Species Projects

Sub-Saharan Africa

Black-footed cat (*Felis nigripes*): Category 1

18. Natural history of the black-footed cat*

Objective: To continue the first study of the behavior and ecology of the black-footed cat in order to gather basic biological information and better understand species status.

Description: Three cats have been radio-collared on a private game reserve in the Kimberley region of South Africa, and over 600 hours of observation data have been gathered so far. The study, sponsored in part by the Mammal Research Institute of the University of Pretoria, will continue to focus on the following problems: (1) home range size, density, and variation in seasonal activity patterns; (2) diet; (3) breeding and denning behavior; (4) blood chemistry (in order to answer questions encountered during captive breeding: see Species Account); (5) intraspecific variation through the study of skins and skeletal material from various southern African collections, and (6) the gathering of biological samples from other parts of the species range in cooperation with the project described below.

Annual budget: II

Time frame: 2-3 years

Contact: A. Sliwa, Mammal Research Institute, University of Pretoria, Pretoria, South Africa.

19. Distribution of the black-footed cat

Objective: To map the distribution of the black-footed cat and gather information on species status.

Description: The black-footed cat has an unusually restricted range in southern Africa, and is generally considered rare. However, there are reportedly certain areas where black-footed cats are relatively abundant. Presence/absence surveys will be conducted in South Africa, Namibia, and Botswana; and possible species occurrence in Angola, Zimbabwe, and Mozambique will be investigated. Survey results will aid range delineation and population status assessment. Data will also be collected on the occurrence of sympatric cat species, with emphasis on the wildcat and domestic cats, with which black-footed cats may hybridize.

Annual budget: I-II

Time frame: 2 years

African golden cat (*Profelis aurata*): Category 1

20. Natural history of the African golden cat*

Objectives: To continue the first study of the behavior and ecology of the African golden cat in order to gather basic biological information and better understand species status.

Description: Preliminary data on diet has been gathered from a study of golden cat scats in Zaire's Réserve de Faune Okapi in the Ituri Forest (J. Hart and M. Katembo in prep.). Future work will use radio-telemetry to study behavior, ecology, habitat use, and abundance. This project will yield the first scientifically gathered data on the natural history of this species.

Annual budget: I-II

Time frame: 2 years

Contact: John Hart, Research Associate, WCS, Epulu via Mambasa, P.O. Box 21285, Nairobi, Kenya. U.S. address: Wildlife Conservation Society/NYZS, Bronx Zoo, Bronx, NY 10460.

21. Distribution of the African golden cat

Objectives: To map the distribution of the Asiatic golden cat and compile information on species status.

Description: Working with recent forest cover maps, the project will conduct presence/absence surveys in selected parts of the African golden cat's range to clarify population distribution, connectivity, and status. Where possible, biological samples will be collected for genetic and morphological analysis. Data will also be collected on occurrence of sympatric cat species.

Annual budget: I

Time frame: 3 years

Cheetah (*Acinonyx jubatus*): Category 2(A)

22. Support for the Cheetah Conservation Fund*

Objective: To promote cheetah conservation in Namibia and other African range states, with concentration on cattle ranching lands outside protected areas.

Description: The Cheetah Conservation Fund (CCF) was established in Namibia in 1990. Its primary activity is working with the cattle ranching community (through lectures, visits, and a newsletter) and the government to promote ways in which cheetah depredation of livestock can be minimized. The CCF is also in a position to evaluate the contribution to cheetah conservation of economic use options developed by Namibia, chiefly trophy hunting and sale of live animals for international breeding programs (permitted under a CITES Appendix I quota system), but also including tourism on game ranches, a growing industry in southern Africa. The CCF is conducting a radio-telemetry study to examine the ecology and social organization of cheetahs on farmland, has built up a substantial database of samples for genetic analysis and for support of the captive cheetah population, and is carrying out extensive public education programs.

Annual budget: V

Time frame: Ongoing

Contact: Laurie Marker-Kraus and Daniel Kraus, Cheetah Conservation Fund, P.O. Box 247, Windhoek 9000, Namibia. U.S. address: c/o International Wilderness Leadership (WILD) Foundation, 211 West Magnolia, Fort Collins, CO 80521.

23. Factors limiting cheetah populations outside protected areas*

Objective: To compare cheetah reproductive and mortality rates between populations living in (1) protected areas;

(2) commercial cattle ranching areas; (3) pastoralist grazing lands.

Description: Cheetah numbers in the Serengeti National Park, Tanzania, appear to be limited by very high rates of cub mortality caused by other large carnivores, chiefly lions. Cheetahs may thus exist at higher densities outside protected areas where other large carnivores have been largely eliminated. Radio-telemetry studies using consistent methodology will compare the population dynamics of cheetahs in the Serengeti to populations found in (1) commercial cattle ranches in Namibia or Zimbabwe and (2) pastoralist lands in Kenya or Tanzania. This data will lead to better understanding of the relative importance of the various factors limiting cheetah numbers in such areas.

Annual budget: III

Time frame: 4-5 years

Contact: Karen Laurenson, Upland Research Group, The Game Conservancy, Crubenmore Lodge, Newtonmore PH20 1BE, U.K.

24. Support for the Serengeti Cheetah Project*

Objective: To continue the long-term study of the ecology of cheetahs in the Serengeti ecosystem.

Description: In cooperation with the Serengeti Research Institute, the Serengeti Cheetah Project was initiated in the late 1970s. The project provides detailed information on demographic rates, lifetime reproductive success and movements of individually known cheetahs living in Tanzania's Serengeti National Park. It is the only such data set for cheetahs, and is important for purposes of comparison with cheetahs living in other ecosystems. The project's current activities are as follows: (1) collection of demographic records on known cheetahs; (2) establishment of a new study area for long-term research on woodland cheetahs; (3) assessment of relative merits for cheetahs of woodland and plains habitat; (4) determination of the means by which cheetahs coexist with their main competitors, lions and hyenas; (5) using data gathered for 1-4 to construct computer models for predicting minimum reserve sizes for viable cheetah populations in different habitats and for varying densities of other predators.

Annual budget: II

Time frame: Ongoing

Contact: Sarah Durant (Project Director), Institute of Zoology, Regent's Park, London, NW1 4RY, U.K. Tanzania address: Serengeti Wildlife Research Institute, c/o TANAPA, Box 3134, Arusha.

25. African cheetah status survey*

Objective: To continue compilation of data on the distribution and status of cheetah populations on a regional basis.

Description: As part of a Ph.D. thesis project, status surveys (interviews) have been carried out in Kenya, Tanzania, and Uganda in east Africa, and in Malawi, Zimbabwe, Botswana, South Africa, and Namibia in southern Africa over a two-year period. To complete coverage of these two regions, the project executant will conduct interviews next in Zambia, where cheetahs are believed to be more rare, but there is little recent available information. Survey results will form the basis for a detailed population distribution map and prioritization of conservation action. Data analysis will focus on determining which specific combinations of ecological and anthropogenic parameters allow healthy cheetah populations to survive.

Annual budget: III

Time frame: 2 years

Contact: Paule Gros and Tim Caro, Wildlife and Fisheries Dept., University of California, Davis, CA 95616, U.S.A.

26. Distribution, status, and captive breeding of cheetah in Zimbabwe*

Objectives: To update presence/absence surveys conducted several years ago and to capture problem animals on commercial cattle ranches for inclusion in a captive-breeding program at Chipangali Wildlife Trust.

Description: The Chipangali Wildlife Trust is concerned that as a result of the legal hunting of cheetahs on license in Zimbabwe, under a quota system, and the fact that cheetahs are still killed illegally in the country, the population could be severely reduced in the near future. This project will conduct presence/absence surveys and compare the results to those carried out in the mid-1980s, and will build up the Trust's captive cheetah population through incorporation of wild problem animals.

Annual budget: II

Time frame: 5 years

Contact: Vivian Wilson, Chipangali Wildlife Trust, P.O. Box 1057, Bulawayo, Zimbabwe.

27. Cheetah census and disease surveillance in Kenya*

Objectives: To conduct presence/absence surveys for cheetahs in Kenya and estimate population size; and to establish the prevalence and importance of scabies/mange and other diseases in wild cheetahs and methods of treatment.

Description: The Kenya Wildlife Service, through its field personnel, will collect data on cheetah distribution and numbers, as well as field samples for analysis of exposure to disease. Treatment and evaluation of effect will be tried out.

Annual budget: I

Time frame: 1-2 years

Contact: Richard Kock, Kenya Wildlife Service, P.O. Box 40241, Nairobi, Kenya.

Lion (*Panthera leo*): Category 2(A)

28. Pan-African lion survey*

Objectives: To continue to conduct presence/absence surveys (mail questionnaire, field surveys in key areas) to obtain a detailed distribution map of lion populations in Africa.

Description: Lions are increasingly confined to protected areas, and unprotected blocks of habitat which still harbor large or significant lion populations need to be identified. The African Carnivore Survey has compiled survey data on lion distribution in southern Africa, and will focus next on west African countries. East Africa will be surveyed largely by mail questionnaire. The result will be a detailed map of lion population distribution to aid prioritization of conservation action.

Annual budget: III

Time frame: 2 years

Contact: Chris and Tilde Stuart, African Carnivore Survey, P.O. Box 96, Nieuwoudtville 8180, South Africa.

29. Predator-prey relationship between lions and large ungulates in South Africa's Kruger National Park*

Objective: To measure the impact of lion predation on prey species.

Description: It is important for the management of the Kruger ecosystem, which contains one of the largest protected lion populations in Africa, to understand the relationships between predators and prey. Lions are the dominant large predators in Kruger. A doctoral student will conduct radio tracking and direct observations of lions, as well as aerial surveys of prey populations and distribution. The data will be used to test and refine theoretical models of lion-prey interaction (Mills and Shenk 1992).

Annual budget: I

Time frame: 2-3 years

Contact: P.J. Funston and Gus Mills, Kruger National Park, Private Bag X402, Skukuza 1350, South Africa.

30. Support for the Serengeti Lion Project*

Objectives: To continue the long-term study of lion behavior and ecology in the Serengeti ecosystem.

Description: The Serengeti Lion Project is the longest-running and most extensive study of wild cats in the world. Detailed demographic records have been compiled on individual lions from two different Serengeti habitats: the plains and the Ngorongoro Crater. The Project has provided baseline data on many aspects of lion biology, including the evolution of sociality, and made an important contribution to wider issues in cat conservation, including population genetics and the effects of disease upon population dynamics. The Project will continue to study these subjects through weekly monitoring of 18 Serengeti lion prides and regular collection of biological samples.

Annual budget: V

Time frame: Ongoing

Contact: Craig Packer (Project Leader), Dept. of Ecology, Evolution and Behavior, University of Minnesota, 1987 Upper Buford Circle, St. Paul, MN 55108, U.S.A.

31. Support for the N!aiuh Project in the Namibian Kalahari*

Objectives: To continue training Ju/hoan Bushman trackers to act as problem animal control officers in northeastern Namibia; and to develop revenue-raising options for local people as an incentive to conserve big cats.

Description: As part of the Namibian government's developing sustainable use of wildlife program for northeastern Namibia, the project will continue to work with local trackers to solve problems of lion predation on livestock. Stock-raiding lions are tracked down and radio-collared, and their movements monitored. The area is home to Bushman communities whose traditional knowledge of wildlife is in danger of being lost. The project aims to develop solutions which will allow rudimentary cattle raising to develop alongside healthy populations of wild ungulates and large predators, and to work with the community to develop economic use options based on use of wild lands and wild animals (with trophy hunting of leopards currently being the most feasible), which will provide badly-need revenues to the community. The project in Bushmanland is an example of a growing movement in Africa to develop economic use options for wild lands, and to cede control and management of wildlife to local residents. This project will be a test case of whether the conservation of dangerous problem animals such as lions can be assured under such conditions.

Annual budget: III

Time frame: 3 years

Contact: Philip Stander, Ministry of Wildlife, Conservation and Tourism, P.O. Box 17, Grootfontein, Namibia.

32. Resolving lion and livestock conflicts in west Africa

Objectives: To evaluate the extent of livestock loss to lions in a west African country; to evaluate the threat posed to lion populations by persecution; and to develop appropriate management solutions applicable to the region.

Description: Lions are patchily distributed through the wooded savannahs of west Africa. This region is an important part of the species range: while the lion has not yet been eliminated from private lands and restricted to protected areas, this process is well under way. The project will select a west African study area which has a relatively large population of lions occurring on private lands where the predominant form of land use is mixed agriculture and livestock husbandry. The extent of livestock depredation will be investigated and quantified, and various management solutions tried out. Local involvement will be key to the success of this project, the results of which will be highly relevant to the survival of the lion outside protected areas elsewhere on the continent.

Annual budget: II-III

Time frame: 3 years

Serval (*Leptailurus serval*): Category 3

No projects suggested for sub-Saharan Africa, although some data on distribution and status will be collected in the course of surveys for sympatric cat species (Projects 19 and 21). For the north African serval, see Project 40.

Leopard (*Panthera pardus*): Category 4(A)

33. Evaluation of the effects of sport hunting on leopard population dynamics

Objectives: To evaluate the impact of sport hunting on leopard populations and test the leopard population model developed by Martin and de Meulenaer (1988); and to make recommendations for management of leopard sport hunting.

Description: Leopard sport hunting is carried out on concessions in several African countries, but the effects on population structure and dynamics have never been studied. Sport hunting is viewed as the major component of a sustainable use leopard conservation strategy on the subcontinent. Leopard population dynamics and response to varying degrees of offtake have been modeled by Martin and de Meulenaer (1988), but their models have not yet been field-tested. This radio-telemetry study will compare the population dynamics of a protected population of leopards to one that is subject to sport hunting. The project will also test the hypothesis that leopards exhibit complete compensation.

Annual budget: III

Time frame: 2-3 years

34. Leopard ecology and density in tropical African rain forest*

Objectives: To continue study of the natural history of leopards in African tropical rain forest, and estimate their numbers in this habitat type.

Description: Tropical rain forest makes up a large part of the leopard's sub-Saharan range, but little is known of their natural history in this type of habitat. It has been predicted that leopards are most abundant in tropical rain forest, if density increases with rainfall (Martin and de Meulenaer 1988). Continuing study of leopards in the Ivory Coast's Taï National Park and the Ituri Forest in Zaire will provide important data for understanding the status and ecology of the leopard. In addition, blood samples will be collected for analysis of genetic differentiation and diversity.

Annual budget: II

Time frame: 2-3 years

Contact: Ivory Coast: Frédéric Dind, B.P. 20, Parc National de Taï, Cote d'Ivoire. Switzerland address: c/o Christophe Boesch, Institute of Zoology, University of Basel, Rheinsprung 9, Basel. Ituri forest, Zaire: John Hart, Research Associate, WCS, Epulu via Mambasa, P.O. Box 21285, Nairobi, Kenya. U.S. address: Wildlife Conservation Society/NYZS, Bronx Zoo, Bronx, NY 10460.

Caracal (*Caracal caracal*): Category 4

No projects suggested for this region, but see related Project 42 in India.

African wildcat (*Felis silvestris, lybica* group): Category 5

No specific projects suggested for this region, but see related Projects 10, 15, and 43. Some distribution data will be gathered by Project 19.

North Africa and Southwest Asia

Asiatic lion (*P. leo persica*): Category 1

35. Establishment of a second population of Asiatic lions in India*

Objective: To establish a second population of Asiatic lions in a selected reserve in India.

Description: India's Gir Forest holds the world's only population of Asiatic lions. The lions appear to be at maximum density, and there are continual problems with lions emigrating into settled areas, killing both livestock and people. The single population, while large, is still vulnerable to stochastic events, and establishment of a second population should both (1) substantially lessen the vulnerability of wild Asiatic lions and (2) relieve the problem of lion depredation in the Gir Forest. A recent PHVA workshop (Walker 1994) evaluated potential release sites and selected Palpur Kuno Wildlife Sanctuary as the most promising. In cooperation with the Wildlife Institute of India and the state and national governments, a feasibility study is being carried out. Lions moved from the Gir to the release site would be genetically sampled and marked or radio-collared.

Annual budget: V

Time frame: 3-5 years

Contact: Ravi Chellam and A.J.T. Johnsingh, Wildlife Institute of India, P.O. Box 18, Chandrabani, Dehra Dun 249 001, Uttar Pradesh, India.

Cheetah (*A. jubatus*): Category 1(A)

36. Conservation of the Asiatic cheetah in Iran

Objectives: To develop and implement a conservation management plan for the cheetah in Iran.

Description: The Iranian population is the only remaining cheetah population in Asia and the largest in the north African-southwest Asian region, but it is in serious danger of extirpation, with numbers estimated at fewer than 50. These cheetahs may be different—at least in terms of natural history, and in terms of morphology and genetics—from sub-Saharan cheetahs. The population is fragmented, low density, and declining from habitat degradation and persecution of both cheetahs and their antelope prey. In the first year, this project will map the distribution of cheetahs in Iran; collect samples for molecular analysis; prioritize populations for conservation; and produce a conservation management plan. In the second year and thereafter, recommendations for action will be carried out.

Annual budget: I-IV

Time frame: 3-5 years

37. Natural history, genetics, and conservation status of the cheetah in the Saharan region

Objectives: To conduct the first study of the behavior and ecology of the cheetah in the Saharan desert region; to collect samples for genetic analysis; and to assess its conservation status.

Description: The cheetah is the last big cat to survive in the Saharan desert, where the habitat is very different from the places cheetah ecology has been studied, in east and southern Africa. Cheetahs are very sparsely distributed in the Sahara, with populations centered around mountain ranges; there may be fewer than 200 animals across the entire desert region. This project will examine the physiological and behavioral adaptations which have enabled cheetahs to persist in the Sahara, evaluate intraspecific diversity through genetic comparison with east and southern African animals, and aid assessment of the cheetah's conservation status throughout the region by providing baseline data on ecology, prey requirements, abundance, and such human-related factors as livestock depredation. Appropriate study areas include the Tassili and Hoggar mountains of southeastern Algeria, or the Termit Massif region in northeastern Niger.

Annual budget: II

Time frame: 2-4 years

See also related Project 78.

Serval (*L. serval*): Category 2(A)

38. Survey for the leopard and the serval in the Atlas Mountains of Morocco*

Objective: To identify whether leopards and servals still exist in the Atlas Mountains of Morocco and selected parts of northern Algeria.

Description: Leopards and servals are rare and possibly extinct in the humid scrub and mixed woodlands of north Africa. These animals are likely to have been isolated from populations south of the Sahara for at least 7,000 years and perhaps much longer, and represent an important potential reservoir of intraspecific diversity. In cooperation with the governments of Morocco and Algeria and the Rabat Zoo, presence/absence surveys will be conducted using interviews as well as confirmatory techniques.

Annual budget: II

Time frame: 1 year

Contact: Haddane Brahim, Parc Zoologique National de Rabat, B.P. 4142, 12000 Temara, Morocco. Switzerland address: Cat Specialist Group Chairman, 1172 Bougy, Switzerland.

Leopard (*P. pardus*): Category 3(A)

39. Distribution and conservation status of the leopard in north Africa and southwest Asia*

Objectives: To hold a workshop of regional cat specialists to map out current distribution of the leopard in the region, assess population status, and coordinate conservation action.

Description: Leopards are the last big cats to survive in any numbers in the region, but their distribution is highly localized, with small populations in low numbers. It is necessary to map out population distribution and prioritize conservation action, especially lobbying for creation of reserves in key areas. A workshop will be held inviting professionals from north African and southwest Asian countries, including Turkey and the Caucasus republics. The workshop will issue recommendations for conservation action by national authorities, and will establish a regional network of professionals to improve coordination and information sharing.

Annual budget: III

Time frame: 1 year

Contact: Peter Jackson, Cat Specialist Group Chairman, 1172 Bougy, Switzerland.

40. Support for the Arabian Leopard Trust*

Objectives: To promote conservation of the leopard (and other felids) on the Arabian peninsula through governmental lobbying, public education, and captive breeding.

Description: Based in the United Arab Emirates, the Arabian Leopard Trust was set up in 1993. Its activities focus on: (1) public education campaigns about the threatened status of the cats of the Arabian peninsula, particularly the leopard; (2) improving regional management of captive cat populations; (3) lobbying for legal prohibition of cat hunting; (4) lobbying for reserve creation; (5) assessing the feasibility of reintroducing large antelope prey species raised in captivity (as was done successfully for the Arabian oryx).

Annual budget: III

Time frame: Ongoing

Contact: Marijcke Jongbloed, Arabian Leopard Trust, P.O. Box 12119, Dubai, United Arab Emirates.

Sand cat (*Felis margarita*): Category 4

41. Distribution of the sand cat

Objectives: To map the distribution of sand cat populations and assess species status in key parts of its range.

Description: It is not clear whether major gaps in the sand cat's range occur in northeastern Africa and Iran, and the status of the southeasternmost population in the deserts of Afghanistan and Pakistan is unknown. Presence/absence surveys in selected areas of western Egypt, Libya, Chad, and Sudan will be overseen by a Cat Specialist Group regional coordinator. Surveys will also be conducted in selected parts of Iran, the Registan Desert of Afghanistan, and selected parts of Baluchistan, Pakistan (see Project 78).

Annual budget: II

Time frame: 2 years

Caracal (*C. caracal*): Category 5a (A)

42. Natural history, distribution, and status of the caracal in India*

Objectives: To map caracal presence/absence, conduct a detailed field study of its behavior and ecology, and assess species status at the eastern limits of its range.

Description: The caracal is believed to be rare in India, and in all of its Asian range natural history has been studied only in an agricultural area of Israel. In cooperation with the Wildlife Institute of India and State Forestry Departments, the project executant will conduct presence/absence surveys for the caracal in India, including both protected areas and key areas of unprotected habitat, notable among them Kutch division of Gujarat, the Gwalior division of Madhya Pradesh and the Aravalli Hills of Rajasthan. Distribution will also be collected for other sympatric small cat species. Survey results will form the basis for population distribution maps, and will aid better understanding of species status. Meanwhile, the ecology and behavior of the caracal in this region will be the focus of a radio-telemetry study in the Sariska Tiger Reserve, Rajasthan.

Annual budget: II

Time frame: 2-3 years

Contact: S.P. Goyal, Shomita Mukherjee, and A.J.T. Johnsingh, Wildlife Institute of India, P.O. Box 18, Chandrabani, Dehra Dun 248 001, Uttar Pradesh, India.

Jungle cat (*Felis chaus*): Category 5a

No projects suggested for this region. Some information on distribution will be collected by Project 80.

Wildcat (*F. silvestris, lybica* group): Category 5b

43. Natural history, status and captive breeding of the wildcat in Israel*

Objectives: To map the distribution of wildcat populations in Israel; to assess the degree of hybridization with domestic cats; to study the behavior and ecology of "pure" wildcats in the wild; and to improve the captive breeding of "pure" wildcats at the Tel Aviv University Research Zoo.

Description: Wildcats are becoming increasingly rare in southwest Asia, and the degree of hybridization with the domestic cat has not been well assessed for this region. This is of special interest, as it is in this region that the wildcat was probably originally domesticated. The behavior and ecology of "pure" wildcats has not been studied across *lybica's* entire range. Tel Aviv University maintains an important captive population of wildcats, descended from founders captured nearly 40 years ago. Their facilities need to be improved, and the offspring circulated in an international captive breeding program (see related Project 15).

Annual budget: III

Time frame: 5 years

Contact: Heinrich Mendelssohn, University of Tel Aviv, Faculty of Life Sciences, P.O. Box 39040, Ramat Aviv 69978, Tel Aviv, Israel.

Tropical Asia

Tiger (*Panthera tigris*): Category 1(A)

44. Protection of the Amur tiger and its habitat in the Russian Far East*

Objectives: (1) To support anti-poaching operations to improve protection of the largest remaining population of

Amur tigers; (2) to conserve a sufficient amount and array of high quality habitat for tigers and other wildlife to maintain viable populations and ecosystem functions over the long-term; and (3) to increase conservation and environmental awareness throughout the region through public education initiatives.

Description: Amur tigers in Russia, home to most remaining animals of this subspecies, have come under intensive poaching pressure in the last few years. There are perhaps no more than 150-200 remaining. This project has been put together by a broad coalition of NGOs to support the Russian government in its efforts to protect the tiger. Activities include the following: (1) strengthening the ranger forces of the Lazovskiy and Sikhote-Alin Nature Reserves; (2) creating and supporting mobile federal anti-poaching brigades on a regional level and local community game guard patrols to safeguard tigers outside protected areas; (3) assisting Russian Customs with technical training to improve enforcement of trade bans; (4) publicizing the strengthening of anti-poaching measures; (5) improving protected area coverage for the tiger by expanding existing areas, establishing new reserves, creating conservation management areas and protecting corridors between them; (6) monitoring the impact of timber and mining extraction on tiger populations and promoting sustainable forestry practices; (7) using Geographic Information System (GIS) map databases to assist these processes; (8) working with Russian NGO counterparts to broaden public awareness and support for tiger conservation. Cooperating organizations include: Ministry of Environmental Protection and Natural Resources of the Russian Federation, the Pacific Institute of Geography and Soils, WWF-Germany, WWF-U.S., the Primorski Regional Association of Indigenous People, the Hornocker Wildlife Research Institute (U.S.), the Tiger Protection Society (Russia), the Tiger Trust (U.K.), and the Siberian Tiger Conservation Network (U.S.).

Annual budget: V

Time frame: 5 years

Contact: Georg Schwede, WWF Germany, P.O. Box 701127, 6000 Frankfurt A/M 70, Germany.

45. Behavior and ecology of the Amur tiger*

Objectives: To continue the first radio-telemetry study of the Amur tiger in Russia's Sikhote-Alin Biosphere Reserve.

Description: The first study of the Amur tiger, using snow tracking and radio-telemetry, began in 1991 in Russia's Sikhote Alin Biosphere Reserve. Russian and American researchers from the U.S.-based Hornocker Wildlife Research Institute are collecting baseline data which will be used to document the tiger's spatial organization, habitat utilization, and population dynamics. Understanding of these variables will facilitate the creation of an appropriate reserve system for the Amur tiger, which occurs mainly outside of protected areas. This project works in close cooperation with Projects 44 and 67.

Annual budget: V

Time frame: 2-3 years

Contact: Dale Miquelle, Sikhote-Alin Reserve, Terney, Primorye Territory, Russia. U.S. address: Howard Quigley, President, Hornocker Wildlife Research Institute, P.O. Box 3246, University Station, Moscow, ID 83843.

46. Conservation of the South China tiger*

Objectives: To develop and implement a conservation management plan for the South China tiger.

Description: The South China tiger is not only the most primitive tiger subspecies, and probably ancestral, but also the rarest, with only 30-80 animals left in highly-fragmented habitat in south-central China. It will almost certainly disappear in the very near future unless active effort is made to conserve it, as the present sub-populations are probably too small, fragmented, and threatened to persist in the long-term. This project, sponsored in part by the Chinese government, will develop and implement a conservation management plan for the subspecies. Activities will include support for improved reserve management in key protected areas, creation of new reserves to preserve habitat corridors between sub-populations, and a variety of socio-economic development projects to reduce conflict between local people and wildlife authorities.

Annual budget: V

Time frame: 5-10 years

Contact: Gui Xiaojie, Hunan Provincial Dept. of Forestry, 39 Nan Da Road, Changsha 410 007, Hunan, China. Meng Sha, Ministry of Forestry, Hepingli, Beijing 100 714, China. Switzerland address: Cat Specialist Group Chairman.

47. Support for Global Tiger Patrol*

Objectives: To improve conservation of the tiger throughout its range by building support among people living outside tiger reserves through community development initiatives, and by establishing an award/incentive program for anti-poaching personnel.

Description: The tiger is seriously threatened by commercial poaching pressure throughout its range. India holds the largest population of tigers and has invested heavily in their conservation. A massive effort is needed to protect tiger populations from catastrophic losses to poaching. The Global Tiger Patrol, formerly the Ranthambhore Society, was established in the U.K. in 1992 to set up community development programs around key protected tiger populations to encourage local support for their conservation and thereby reduce poaching. Global Tiger Patrol is also setting up, with the cooperation of the Indian government, an award scheme for game guards who capture poachers. This project, partly supported by the European Union, is actively expanding Global Tiger Patrol's activities to other tiger range states.

Annual budget: V

Time frame: Ongoing

Contact: Peter Lawton, Director, Global Tiger Patrol, 19 Kautilya Marg, New Delhi 110 021, India.

48. Improving the reliability of tiger censuses in India*

Objective: In collaboration with the Government's Project Tiger Directorate, to conduct a workshop to improve tiger census techniques by evaluating the appropriateness for different habitat types of various methods, including photo traps, statistical analysis of pugmark measurements, and trend estimates by field staff

Description: The Indian government has estimated tiger numbers for the past 20 years from pugmark censuses, but the accuracy of the technique has been challenged. The present tiger poaching crisis demands that reliable, rapid, and inexpensive methods of estimating tiger numbers be developed so that the status of tiger populations can be accurately monitored. Refined, computerized analysis of pugmarks, photo-trap transect surveys, and trend estimates by field staff require evaluation. The workshop will review and field test these techniques.

Annual budget: III-IV

Time frame: 1 year

Contact: Valmik Thapar, Cat Specialist Group Vice-Chairman for Asia, 19 Kautilya Marg, New Delhi 110 021, India.

49. Distribution, abundance, and ecological and conservation status of the tiger in India*

Objective: To evaluate the status of the tiger in Project Tiger reserves and other areas.

Description: Despite a series of all-India censuses from 1972-1993, there is still considerable uncertainty about the exact distribution and number of tigers in India, most of which live outside the 21 Project Tiger reserves. This information is essential in order to assess the survival prospects of the tiger in India and to improve conservation management. Basic ecological data on habitat and prey availability outside the special reserves is lacking. Rigorous techniques for assessing these parameters have not been developed and applied. These lacunae were highlighted by the government of India during the international symposium on tiger in New Delhi in 1993. In northern India, the project executant will visit reserves and other tiger areas to collect information on the distribution of tiger populations, population structure, and reproductive and survival rates. In southern India, the project executant will conduct 16 weeks worth of field work at each site, with the aim of developing a standardized methodology for measuring habitat quality, tiger numbers and prey densities, as well as predictive models to evaluate tiger population status based on these parameters. There will be close collaboration with Project 48.

Annual budget: III

Time frame: 3 years

Contact: Northern India: S. Deb Roy IFS (Retd), 24/4 Type 5, Lodi Complex, New Delhi 110 003, India. Southern India: K. Ullas Karanth, Center for Ecological Studies, 499 Chitrabhanu Road, Kuvempu Nagar, Mysore 570 023, Karnataka, India. U.S. address: c/o NYZS/ Wildlife Conservation Society, Bronx Zoo, Bronx, NY 10460.

50. Conservation of viable tiger populations in India: the effects of population isolation and movement corridors

Objectives: To evaluate, as part of Project Tiger, the viability of small and isolated tiger populations, as well as the potential of corridors between them to improve viability; to map the presence of potential corridors throughout the country and to survey these areas to confirm use by tigers; to undertake measures to ensure conservation of important corridors.

Description: This is a pilot project relevant to big cat conservation. India holds the world's largest population of tigers, and has been outstanding in its commitment to tiger conservation. Project Tiger is based upon conservation of tigers in protected areas which are representative of the diversity of tiger habitat. Many of the reserves, as well as other areas with tigers, are isolated, and may be too small to harbor tiger populations of a sufficient size to ensure long-term viability. Conservation biology theory predicts that even a very low level of immigration can substantially improve the viability of otherwise isolated populations. This long-term study, in cooperation with the Wildlife Institute of India, will investigate the effects of population isolation and corridors on tiger populations and their conservation.

The project has three components. The first is a long-term study to compare the health and dynamics of three populations: a small isolated population; a large isolated population; and a population undergoing occasional immigration of new animals through a corridor. Study sites will be selected which are of similar size and habitat composition. The necessary legal measures should be taken to assure the integrity of the habitat corridor for the duration of the study, but this should not necessarily preclude human activity. The tigers will be sampled for molecular analysis of genetic diversity and kinship, and for reproductive parameters. The second and parallel component will be to identify potential corridors linking key tiger populations elsewhere in India, and conduct sign surveys to validate actual use. The third component will be for the Indian government to undertake any legal measures necessary to preserve the viability of corridors.

Annual budget: I-V

Time frame: Long-term (10+ years)

51. Support for the Ranthambhore Foundation's eco-development project*

Objectives: To support the Ranthambhore Foundation's exemplary project aimed at improving the living standards of local people around the Ranthambhore Tiger Reserve, promoting their understanding of the value of wildlife reserves, and thereby gaining their support for conservation.

Description: The Ranthambhore Tiger Reserve in northern India became world famous in the 1980s for the opportunities it provided to view tigers in the wild. However, local people have suffered from near exhaustion of natural resources outside the reserve, as well as suffering depredation of crops by wild animals. Conflict with reserve staff has occurred when people sought to graze their cattle and collect wood and fodder within the protected area. Ranthambhore exemplifies the situation of many reserves with tiger populations in the Indian subcontinent and elsewhere. The Ranthambhore Foundation was established in 1988 to remedy the situation by establishing a sustainable development program to improve the livelihood of people living around the reserve. The Foundation works in seven villages, and its activities include: growing trees for firewood, timber, and fodder for livestock; rehabilitating denuded grazing lands; providing new high-yielding cattle breeds adapted to stall feeding; organizing marketing of milk; providing medical and family planning facilities and health education; organizing income producing activities for women (e.g., traditional needlework, which is marketed in the cities); and providing environmental education for all, but especially the children, with audio-visuals and visits to the reserve. The success of the project has attracted international attention and support.

Annual budget: III

Time frame: Ongoing

Contact: Valmik Thapar, Honorary Director, Ranthambhore Foundation, 19 Kautilya Marg, New Delhi 110 021, India.

52. Support for the Tigerhaven Wildlife Trust*

Objectives: To mitigate conflict between tigers of India's Dudhwa National Park and local people living on the park boundaries by paying livestock loss compensation.

Description: Dudhwa National Park is home to an important tiger population in northern India, and there is a high level of conflict between people and tigers in the vicinity. Sugarcane is grown right up to park borders, providing attractive habitat for park wildlife, including tigers, which often breed there. There have been numerous incidents of human deaths and livestock predation, while there has been evidence of poaching, for which there is a strong incentive because of the current high value of tiger products for smuggling to China. Most of India's tiger reserves are situated in areas with high human populations, and the government's program of compensation for loss of livestock has not functioned smoothly. This pilot project will test the ability of an NGO to deal effectively with the problem.

The Tigerhaven Wildlife Trust will liaise with communities on the periphery of Dudhwa National Park to establish a pilot compensation scheme for loss of livestock, paid from a trust fund managed by the NGO.

Annual budget: I-II

Time frame: Ongoing

Contact: Arjan Singh, Tigerhaven Wildlife Trust, P.O. Pallia, Box 8, Dist. Kheri 262 902, Uttar Pradesh, India.

53. Current distribution of tiger populations in east and southeast Asia*

Objectives: To identify current population distribution and status of tigers in Bangladesh, Cambodia, Laos, Malaysia, Myanmar, North Korea, Sumatra, Vietnam, and southwest and northeast China.

Description: In cooperation with national governments, Cat Specialist Group and NYZS/Wildlife Conservation Society coordinators will oversee presence/absence surveys for the tiger in southeast Asian range states. The status of the tiger is not well understood in these countries, but there are fears that poaching pressure has led to widespread declines. Preliminary surveys have been carried out in Laos, and surveys are in the process of being set up in southwestern China, North Korea, Sumatra, Vietnam, and Bangladesh. Similar work will also be done in other range states. Survey techniques will rely on networking between regional coordinators and local wildlife officials and other experts. Survey data will be used to compile accurate population distribution maps and prioritize populations for conservation action. These surveys will also collect distribution information on other sympatric cat species.

Annual budget: I-II/per country

Time frame: 1-2 years

Contact: Bangladesh: Anisuzzaman Khan, Nature Conservation Movement, 13 Monipuripara Serebangla Nagar, Dhaka, Bangladesh. Southern and Southwestern China: Lu Houji, Dept. of Biology, East China Normal University, Shanghai 200 062, China. Indonesia (Sumatra): Ronald Tilson, SSP Tiger Coordinator and Director of Conservation, Minnesota Zoological Garden, 13000 Zoo Boulevard, Apple Valley, MN 55124, U.S.A. Laos: Klaus Berkmüller, IUCN-Laos, 15 Fa Ngum Road, Vientiane, Laos. North Korea: Pak U Il, Director, Research Center for Nature Protection, Academy of Sciences, Pyongyang, Peoples Democratic Republic of Korea. Vietnam: Dao Van Tien, Laboratory of Zoology, 19 Le Thanh Tong Street, P. 215 Khu Thanh Cong, Hanoi, Vietnam. Others and Overall: Alan Rabinowitz, Asia Director, NYZS/Wildlife Conservation Society, Bronx Zoo, Bronx, NY 10460, U.S.A. Peter Jackson, Chairman, IUCN/SSC Cat Specialist Group, 1172 Bougy, Switzerland.

54. Support for the Chitwan Tiger Project*

Objectives: To continue the long-term monitoring of the tiger population in Nepal's Chitwan National Park.

Description: The project, run in cooperation with the U.S.-based Smithsonian Institution and the government of Nepal, employs two professional tiger trackers to compile daily records on known tigers. It has provided the only comprehensive set of long-term data on tiger population dynamics.

Annual budget: I

Time frame: Ongoing

Contact: Charles McDougal, Smithsonian Research Associate, Tiger Tops, P.O. Box 242, Kathmandu, Nepal.

55. Development of a tiger population simulation model*

Objectives: To: (1) construct a realistic computer simulation model for tiger populations based on the extensive data set from Royal Chitwan National Park, Nepal; (2) use the model to design an efficient approach for field research; (3) use the model to explore the consequences of poaching on long-term population viability; (4) use the model to explore the potential consequences of inbreeding depression on long-term population viability.

Description: The tiger population simulation model may be used to address the following questions: How are viable populations of tigers protected given limited knowledge? How does one decide whether a population is thriving or in danger of extinction? How important is inbreeding depression from a managerial perspective? Is a given protected area large enough to support a viable population? Would additions or corridors safeguard the population? When is active intervention necessary and what are the likelihoods of success of various types of intervention? Should limited resources be expended on small isolated populations which appear to be doomed to extinction? How should a research program be designed to study tigers to make the most efficient use of limited resources? Are there critical parameters to monitor which would indicate the status of a particular population?

The model has been developed at the University of Minnesota. It is individually-based, stochastic and spatial, and includes detailed behavioral characteristics, such as infanticide and dispersal patterns. The project is to be continued as a graduate thesis.

Annual budget: I

Time frame: 1 year

Contact: J.L. David Smith, Anthony M. Starfield, and John Kenney, Conservation Biology Program, University of Minnesota, St. Paul, MN 55108, U.S.A.

56. Genetic evaluation of subspeciation in the tiger*

Objective: To evaluate subspeciation in the tiger through representative genetic analysis.

Description: Several molecular methodologies are being used to re-examine tiger subspecies in terms of genetics. Tiger subspecies have been well-studied morphologically, but a genetic component is also necessary. Previous efforts have been compromised by a limited selection of captive animals. This study is collecting biological samples from wild-caught animals in Russia, India, Sumatra, and other Asian range states, and will collect biological samples from certified pure-bred South China tigers from Chinese zoos.

Annual budget: III

Time frame: 2 years

Contact: Stephen J. O'Brien, Laboratory of Viral Carcinogenesis, National Cancer Research Institute, Bldg. 560 Room 21-105, Frederick, MD 21702-1201, U.S.A.

Bornean bay cat (*Catopuma badia*): Category 1

57. Natural history, distribution, and status of the Bornean bay cat*

Objectives: To conduct the first study of the behavior and ecology of the Bornean bay cat using radio-telemetry; and to compile information on its distribution and status.

Description: The Bornean bay cat is the least known cat in the world. Nothing is known of its natural history. It has a limited distribution on the island of Borneo and is apparently quite rare. Animals will be captured, radio-collared and sampled for genetic analysis in an appropriate study site. The project coordinator will oversee presence/absence surveys in the Bornean highlands and other parts of the island.

Annual budget: I-II

Time frame: 2-3 years

Contact: Mel Sunquist, 118 Newins-Ziegler Hall, Florida Museum of Natural History, University of Florida, Gainesville, 32611 FL, U.S.A.

Clouded leopard (*Neofelis nebulosa*): Category 2(A)

58. Natural history of the clouded leopard*

Objectives: To conduct the first study of clouded leopard behavior and ecology through radio-telemetry.

Description: A preliminary survey by the Wildlife Institute of India has identified the Dampa Wildlife Sanctuary of Mizoram, India, as a suitable study area. The behavior and ecology of the clouded leopard have never been studied, a major gap in natural history knowledge among the larger cats. This study will provide the first quantitative data to help evaluation of species status.

Annual budget: II

Time frame: 2-3 years

Contact: A.J.T. Johnsingh, Wildlife Institute of India, P.O. Box 18, Chandrabani, Dehra Dun 248 001, Uttar Pradesh, India.

59. Distribution of the clouded leopard and other sympatric small cats*

Objectives: To map the distribution of the clouded leopard and other small cats.

Description: Regional coordinators will oversee presence/absence surveys by networking with local wildlife officials and other experts, and the results will form the basis of a detailed population distribution map. The component in southern and southwestern China is of particular importance due to the wide but patchy distribution of the clouded leopard and Asiatic golden cat in that country. These surveys will also collect distribution data on other sympatric cat species, and will aid evaluation of their status.

Annual budget: I-II

Time frame: 3 years

Contact: Peter Jackson, Chairman, Cat Specialist Group, 1172 Bougy, Switzerland; China: Lu Houji, Dept. of Biology, East China Normal University, Shanghai 200 062, China.

Asiatic golden cat (*Catopuma temmincki*): Category 2

60. Natural history of the Asiatic golden cat

Objectives: To gather the first information on the behavior and ecology of the Asiatic golden cat through radio-telemetry.

Description: The natural history of the Asiatic golden cat has never been studied. It is very difficult to evaluate the status of this vulnerable species lacking such information. A small number of animals will be captured, radio-collared, and monitored in a selected study area.

Annual budget: I-II

Time frame: 2-3 years

For distribution surveys, see Project 59.

Flat-headed cat (*Prionailurus planiceps*): Category 2

61. Natural history of the flat-headed cat

Objectives: To gather the first information on the behavior and ecology of the flat-headed cat through radio-telemetry.

Description: The flat-headed cat has unusual physical features which point to a semi-aquatic existence, but it has never been studied in the wild. A radio-telemetry study will be conducted which looks at the cat's ecology and behavior in both protected wetland habitat and altered habitat, such as oil palm plantations. The results will greatly aid understanding of species status.

Annual budget: I-II

Time frame: 2 years

62. Distribution of the flat-headed cat

Objectives: To map the distribution of the flat-headed cat and assess the species status.

Description: A coordinator will oversee presence/absence surveys for the flat-headed cat in Burma, Thailand, Malaysia and Indonesia. Priority goes to the Isthmus of Kra (Burma and Thailand), a relatively densely settled region which forms the northern limit of its range. Data will also be collected on the occurrence of other sympatric cat species. Survey results will form the basis for a detailed population distribution map.

Annual budget: I-II

Time frame: 2-3 years

Rusty-spotted cat (*Prionailurus rubiginosus*): Category 2

63. Natural history and distribution of the rusty-spotted cat

Objectives: To gather the first information on the behavior and ecology of the rusty-spotted cat through radio-telemetry; and to map distribution through presence/absence surveys.

Description: The rusty-spotted cat has a limited distribution in India, but apparently occurs in a variety of habitats. Its behavior and ecology have never been studied, and its status is unclear. A radio-telemetry study will be carried out to collect baseline data on its natural history and habitat requirements, and presence/absence surveys will be conducted through networking with local officials and other experts.

Annual budget: I-II

Time frame: 2-3 years

Fishing cat (*Prionailurus viverrinus*): Category 2

64. Natural history of the fishing cat*

Objectives: To continue the first comparative radio-telemetry study of the behavior and ecology of the fishing cat and other sympatric cat species.

Description: This project will yield the first scientifically gathered data on the natural history of the fishing cat.

Fishing cats will be captured and radio-collared in Thailand's Huai Kha Khaeng Wildlife Sanctuary, along with other sympatric cat species (leopard cats and leopards have been collared so far). This study will focus on the food habits, habitat use and ecological coexistence of cat species in Asian tropical monsoon forest. Data on the fishing cat will be compared to results from a study of fishing cats in Nepal's Chitwan National Park.

Annual budget: II

Time frame: 2-3 years

Contact: J.L. David Smith, Dept. of Fisheries and Wildlife, 200 Hodsun Hall, University of Minnesota, St. Paul, MN 55108, U.S.A.

65. Distribution of the fishing cat

Objectives: To map the distribution of the fishing cat and assess the status of populations in key large wetlands.

Description: The fishing cat is strongly associated with wetland habitats, and is expected to have a patchy distribution over its range. It may possibly have become extinct along the coast of southwestern India; this area is of top priority for surveys. A Cat Specialist Group regional coordinator will oversee presence/absence surveys in this and other key areas of the fishing cat's range. This will involve networking with local wildlife officials and other experts, as well as site surveys in selected areas. Survey data will form the basis of a detailed population distribution map. Data on the occurrence of sympatric cats will also be collected.

Annual budget: I-II

Time frame: 2 years

Marbled cat (*Pardofelis marmorata*): Category 2

66. Natural history of the marbled cat

Objectives: To gather the first information on the behavior and ecology of the marbled cat using radio-telemetry.

Description: The marbled cat is among the most mysterious in the family Felidae. Nothing is known of its natural history or habitat requirements; capture of animals for study is impeded by their apparent strong arboreality. Its fur pattern is remarkably similar to the sympatric clouded leopard, although several authorities, based on skull characters, have argued that they are not closely related. This study will greatly aid understanding of the species. Animals will be captured, radio-collared, and sampled for genetic analysis at an appropriate study site.

Annual budget: I-III

Time frame: 3-4 years

For distribution surveys, see Project 59.

Leopard (*P. pardus*): Category 3(A)

67. Support for the Far East Leopard Fund*

Objectives: To ensure the conservation of a viable population of Amur leopards in the Russian Far East.

Description: The Amur leopard is the rarest form of leopard, distinctively unique with its large, open rosettes, and with numbers estimated at only 30 animals in Russia, with perhaps a few in North Korea and China. A Russian-American scientific team associated with the Fund (see Project 45) is carrying out the first radio-telemetry study in the Kedrovaya Pad Nature Reserve in Ussuri province. Funds raised by the Far East Leopard Fund will be used to increase anti-poaching protection in the reserve, to initiate a captive breeding program, and lobby for the creation of a new reserve in important leopard habitat.

Annual budget: I-III

Time frame: Ongoing

Contact: Viktor Korkishko, Far East Leopard Fund, Kedrovaya Pad Reserve, Primorsky Krai 692 710, Russia. Switzerland address: Cat Specialist Group Chairman.

68. Leopard ecology in three habitats in India*

Objectives: To gather basic information on the natural history of leopards in three different Indian habitats.

Description: The leopard is the most common large cat out of the five found in India, but next to nothing is known of its behavior and ecology. This information would be valuable for improving management of leopard populations. Preliminary predation data has been gathered from the Gir forest in Gujarat; the two other study sites include Mundanthurai plateau in Kalakad-Mundanthurai Tiger Reserve, and Garhwal-Kumaon Himalaya in the state of Uttar Pradesh, where numerous leopards are killed every year as a result of conflict with humans.

Annual budget: III

Time frame: 5 years

Contact: A.J.T. Johnsingh, Wildlife Institute of India, P.O. Box 18, Chandrabani, Dehra Dun 248 001, Uttar Pradesh, India.

Jungle cat (*Felis chaus*): Category 4

No projects suggested. Some information on distribution will be collected during surveys for other sympatric species in certain parts of the jungle cat's range (Projects 59, 63, 65).

Leopard cat (*Prionailurus bengalensis*): Category 5

See Project 13 under General Topics, Trade. Distribution information will be collected by Projects 59, 62, 63, and 65.

Iriomote cat (*P.b. iriomotensis*): Not ranked, but high priority

69. Evaluation of the taxonomic status of the Iriomote cat*

Objective: To determine the taxonomic status of the Iriomote cat by reconciling the opinions of different experts in the fields of systematics, anatomy, genetics, and ethology.

Description: The Iriomote cat is found only on the small Japanese island of Iriomote, the southernmost island in the Ryuku chain, located about 200 km east of Taiwan. It has variously been considered a monotypic species (*Mayailurus iriomotensis*); a species closely related to the leopard cat (*Prionailurus iriomotensis*); and a subspecies of the leopard cat (*P. bengalensis iriomotensis*). The project executant will liase with the various experts on the Iriomote cat with the aim of producing a consensus decision on how the cat should be scientifically classified. The executant will also work with experts in the Philippines to compare the degree of differentiation of these island populations. The classification of the Iriomote cat has important repercussions for conservation action: is it the world's most endangered cat, or a distinctive island population of one of the world's more common cat species?

Annual budget: II

Time frame: 1-2 years

Contact: Ryuchi Masuda, Naoyi Yukhi and Stephen J. O'Brien, Laboratory of Viral Carcinogenesis, National Cancer Research Institute, Bldg. 560 Room 21-105, Frederick, MD 21702-1201, U.S.A.

70. Conservation of the Iriomote cat*

Objective: To ensure the conservation of viable numbers of Iriomote cats in the wild.

Description: Conservation of the Iriomote cat is politically difficult because most cats occur on the coastal lowlands, rather than the mountainous center of the island where the protected area is, and suffer a high degree of human-related mortality, including road kills. Study of the ecology and population dynamics of the Iriomote cat, sponsored mainly by the Japanese government and continuing now for more than a decade, will shift to the so-far unstudied western portion of the island, where prospects for lowland reserve creation are best due to its relatively low level of development.

Annual budget: V

Time frame: 5 years

Contact: Masako Izawa, Dept. Biology, University of the Ryukus, Nishihara, Okinawa 903-01, Japan.

Eurasia

Asia sub-region

Snow leopard (*Uncia uncia*): Category 1(A)

71. Support for the International Snow Leopard Trust*

Objective: To support the activities of Project Snow Leopard of the International Snow Leopard Trust in Central Asian range states.

Description: The snow leopard ranks with the tiger as the most vulnerable of the big cats. The population is extremely fragmented, and snow leopards are threatened by persecution for livestock predation and by commercial poaching. The International Snow Leopard Trust has developed a substantial body of expertise on the species since its establishment in 1981. It is developing a coordinated information program to monitor the status of snow leopard populations, and to develop a cooperative framework within which range states can work together. The program, called "Project Snow Leopard: Conservation of Central Asian Biodiversity," has six components: (1) involvement of local people in all stages of snow leopard projects; (2) improving management of mountain reserves in snow leopard range states; (3) strengthening local conservation institutions through training and program support; (4) reducing poaching by providing technical support; (5) promoting regional cooperation; and (6) identifying and establishing habitat corridors and trans-boundary reserves.

Annual budget: I-IV (examples: I. development of conservation education materials and dissemination to schools and villages; II. field training workshops for rangers from snow leopard reserves; III. identification of "hotspots" for snow leopard livestock predation, and development of programs to reduce people-wildlife conflicts; IV. identification and protection of habitat corridors.)

Time frame: Ongoing

Contact: Helen Freeman, President, International Snow Leopard Trust, 4649 Sunnyside Ave. No., Seattle, WA 98103, U.S.A.

72. Status and management of snow leopards in Tibet*

Objectives: To determine the status of snow leopards in southeastern Tibet and adjoining areas of China; and to implement measures aimed at reducing illegal trade in bones and furs.

Description: Tibet probably holds the world's largest population of snow leopards. Recent work by G. Schaller, R. Jackson and J. Fox, however, has shown that snow leopard range is considerably more fragmented than previously supposed, with large areas containing very low numbers, or none at all. No status surveys have been conducted in southeastern Tibet, nor have rumors of snow leopard occurrence (along with blue sheep) in Yunnan province and the extreme northern tip of Myanmar been investigated. In the last few years, both ungulate and snow leopard populations have come under increasing poaching pressure. New roads provide relatively easy access to uninhabited terrain, but the vast tracts of land make patrolling extremely difficult. There is an urgent need to train Tibetans and others in survey and habitat assessment techniques, so that key wildlife areas can be identified and protected. Check-posts need to be established in and near protected areas, such as the Changtang and Qomolangma Nature Reserves, and forest department staff provided with cold weather gear and more reliable transport than currently exists. The project plans to incorporate village-level wildlife stewardship and is being developed in Nepal (Project 74).

Annual budget: I-III

Time frame: 5 years

Contact: Rodney Jackson, 18030 Comstock Ave., Sonoma, CA 95476, U.S.A.

73. Evaluation of the status of the snow leopard in Russia and the central Asian republics*

Objectives: To continue assessment of the snow leopard populations of Russia and the central Asian republics; and to produce regionally-based conservation management plans.

Description: The northernmost populations of snow leopard may be sufficiently isolated from the southern populations to warrant taxonomic differentiation; moreover, they are unique in their occupation of coniferous forest habitat. Mapping of population distribution needs to be completed, as well as evaluation of migration possibilities and identification of key habitat corridors. The size of each regional population will be estimated; the possibility of migration exchange between them investigated; and limiting factors identified. Animals will be captured and sampled for genetic analysis. Preliminary field surveys have already been carried out in the Altay, Sayan, and Tuva mountain ranges in southern Siberia, and a detailed ecological study of snow leopards in the western Tian Shan (Kyrgyzstan) has been completed. These areas will be further studied in the first phase of the project. The second phase will move on to the Dzhungarian Alatau in Kazakhstan, and the Pamir and Pamir-Altai in Uzbekistan and Tajikistan.

Annual budget: II

Time frame: 3 years

Contact: Eugene Koshkarev, Tchaikovsky Street 140, Apartment 6, Irkutsk, Russia. U.S. address: c/o International Snow Leopard Trust, 4649 Sunnyside Ave. No., Seattle, WA 98103.

74. Reducing livestock depredation in the Annapurna Conservation Area of Nepal: implementation of a snow leopard management plan*

Objectives: To investigate factors contributing to livestock depredation by snow leopards and leopards in three regions of Nepal's Annapurna Conservation Area (Phase I), and to develop and implement measures to reduce loss of livestock and alleviate related people-wildlife conflict (Phase II).

Description: The recently established Annapurna Conservation Area holds what is probably the country's largest population of snow leopards. Predation by snow leopards on domestic livestock owned by people living in the reserve has been investigated by this project (Phase I: 1991-1993), funded in part by the U.S. Agency for International Development. A number of factors were found to be statistically associated with livestock predation, including inadequate or lack of daytime guarding; close proximity to a cliff; and grazing alongside a well-defined habitat edge, such as pasture adjoining brushy areas, broken terrain, or a valley "bowl." A number of recommendations were generated for reducing livestock losses by the project, and Phase II will focus upon educating herders on improving their livestock herding and guarding practices, and upon establishing the importance of snow leopards as a tourist attraction—a valuable asset rather than a burden to the local people. The project is part of the Annapurna Conservation Area Project run by the King Mahendra Trust for Nature Conservation. This larger project seeks to empower local people in management and conservation of natural resources and wildlife, primarily through eco-tourism.

Annual budget: IV

Time frame: 2 years

Contact: Chandra Gurung, Member Secretary, King Mahendra Trust for Nature Conservation, P.O. Box 3712, Kathmandu, Nepal. Rodney Jackson, 18030 Comstock Ave., Sonoma, CA 95476, U.S.A. Gary Ahlborn, Bio-Systems Analysis, 3152 Paradise Dr. Bldg. 39, Tiburon, CA 94920, U.S.A.

75. Conservation of snow leopards and their habitat in northern Pakistan*

Objectives: To evolve and implement a management strategy for the protection of snow leopard from persecution by grazier communities, and to stop illegal trade of its pelts.

Description: Pakistan holds a small, threatened population of snow leopards, with numbers estimated at 100-200. WWF-Pakistan has initiated some small-scale projects in snow leopard areas which have proved successful. Future activities will include the following: (1) presence/absence surveys to map out snow leopard population distribution; (2) working with grazier communities to improve anti-predator measures; (3) small-scale development programs which enhance crop and livestock productivity to help offset losses to predators; (4) conservation education programs about the snow leopard for both local graziers and the general public; (5) training seminars for local wildlife officials to improve snow leopard protection and enforcement of the trade ban.

Annual budget: III

Time frame: 5 years

Contact: Ashiq Ahmad, Conservation Director, WWF-Pakistan, Department of Environmental Studies, University of Peshawar, Pakistan.

Chinese mountain cat (*Felis bieti*): Category 1

76. Natural history, distribution, and status of the Chinese mountain cat

Objectives: To gather the first information on the behavior and ecology of the Chinese mountain cat through radio-telemetry; and to conduct presence/absence surveys to gain better understanding of its distribution and status.

Description: A study site in the vicinity of Xining (Qinghai province), where Chinese mountain cats have been collected in the past for the Xining Zoo, will be selected. Animals will be captured, radio-collared, and sampled for genetic analysis. The study will examine the natural history of the species, with emphasis on determining habitat suitability to predict presence/absence and help with surveys of the cat's distribution. Such surveys should be conducted in montane regions along the northeastern edge of the Tibetan Plateau. The Xinjiang cat survey (Project 80) will help determine whether the Chinese mountain cat occurs west of its very small known range (see Species Account).

Annual budget: I-II

Time frame: 2-3 years

Manul (*Otocolobus manul*): Category 2

77. Natural history of the manul

Objectives: To gather the first information on the behavior and ecology of the manul through radio-telemetry.

Description: The natural history of the manul has never been studied using radio-telemetry; it appears to be strongly associated with cold steppe grassland habitats. A study site will be selected, and animals captured, radio-collared, and sampled for genetic analysis.

Annual budget: I-II

Time frame: 2-3 years

78. Status of the cheetah, sand cat, and manul in Baluchistan, Pakistan

Objectives: To conduct surveys to determine the status of the isolated populations of the manul and sand cat in western Pakistan; and to investigate whether a resident cheetah population is present.

Description: The montane juniper steppes of Baluchistan are unusual habitat for the manul, and the small populations found there appear to be isolated from the main population (see Species Account). Presence/absence surveys will be conducted and site visits made to ascertain population distribution and status. These surveys will also collect data on the sand cat in the nearby Nushki desert region close to Iran, and potential occurrence of the cheetah.

Annual budget: I-II

Time frame: 1-2 years

79. Status of the manul in the area of the Caspian Sea

Objectives: To conduct presence/absence surveys to determine the status of the manul in Armenia, Azerbaijan, Iran, Turkmenistan, and Uzbekistan.

Description: These countries are home to a reddish form of the manul which has been termed a separate subspecies, the Transcaspian manul *O.m. ferrugineus* Ognev, 1928. The status of this taxon has not been examined in detail, but it is described by the regional Red Data Books as "endangered" (Belousova 1993), and has apparently disappeared in recent years from large areas of its historic range (Bannikov and Sokolov 1984). Presence/absence surveys will be conducted in selected areas of the Caspian region, and the results will form the basis of a detailed population distribution map.

Annual budget: I-II

Time frame: 2-3 years

Asiatic wildcat (*F. silvestris, ornata* group): Category 2

No specific projects suggested. Some data on population status and distribution will be collected by Projects 42, 76, and 78-80. See also Projects 10 and 15.

Eurasian lynx (*Lynx lynx*): Category 3

80. Status survey for the lynx and other small cats in Xinjiang province, China*

Objectives: To map the distribution and evaluate population status of the cats of Xinjiang province, including the Eurasian lynx, manul, Asiatic wildcat, jungle cat, and possibly the Chinese mountain cat.

Description: The arid mountains of central Asia represent unusual habitat for the Eurasian lynx, and animals here are traditionally classified as the subspecies *dinniki*. The status of the lynx and the other cats of Xinjiang is not known. The project executant will conduct wide-ranging presence/absence surveys within China's vast northwestern province, and will focus on investigating the impact of historically high levels of exploitation for furs. Funded mostly by the Chinese government, this project will generate recommendations for conservation action, including better control of hunting.

Annual budget: II

Time frame: 2 years

Contact: Ablimit Abdukadir, Xinjiang Institute of Biology, Pedology, and Desert Research, Urumqi 830 011, Xinjiang, China.

Europe sub-region

Iberian lynx (*Lynx pardinus*): Category 1

81. Implementation of conservation management measures for the Iberian lynx*

Objective: To implement conservation management measures for the largest sub-populations of the Iberian lynx in Spain and Portugal.

Description: The Iberian lynx ranks as the world's most vulnerable cat species, reduced to small sub-populations in fragmented habitat, with total numbers probably not greater than 1,200. However, the cat has been well-studied, the threats facing it are fairly well-known, and guidelines for conservation action (ICONA 1992) must now be applied and tested in the field. These include (1) completion of detailed surveys of the conditions faced by each lynx sub-population (land use, land ownership, habitat condition, rabbit density); (2) population viability analysis and genetic sampling; (3) banning rabbit trapping; (4) taking active steps to increase rabbit populations (such as brush clearance); (5) investigating alternative methods of controlling competing predators of rabbits; and (6) reintroduction-oriented research associated with the captive breeding/rehabilitation program now underway. This project is affiliated with the LIFE program of the European Union, and will work closely with the next Project 82.

Annual budget: IV-V

Time frame: 4 years

Contacts: Spain: Miguel Aymerich, Instituto Nacional para la Conservación de la Naturaleza (ICONA), Gran Via de San Francisco 4, 28071 Madrid, Spain. Portugal: Direcçao de Serviços de Conservaçao da Natureza, Ministerio do Ambiente e dos Recrusos Naturais, Instituto da Conservaçao da Natureza, Rua da Lapa 73, 1200 Lisboa, Portugal.

82. Applied studies on the conservation of the Iberian lynx*

Objectives: To continue the long-term study of the behavior, ecology, and conservation status of the Iberian lynx in Spain.

Description: The Lynx Study Group, based in Coto Doñana National Park, has produced most of the biological data on the Iberian lynx, as well as training a number of students, and clarifying the conservation status and problems of the most vulnerable of the cat species. Future study topics include the following: (1) population status surveys; (2) genetic and pathological research; (3) use of habitat in relation to other predators and development of a general habitat model for the lynx; (4) plan for habitat corridors to avoid fragmentation of distribution areas; (5) models for analysis of population viability; (6) research linked with the Experimental Center for Captive Breeding; (7) pilot reintroduction program for lynx captured or born in captivity; (8) monitoring the effects of habitat management and rabbit restocking programees; follow-up of repopulation of the rabbit and of means of managing habitat; (9) research into alternative means of controlling conflicting predators. This project is affiliated with the LIFE program of the European Union, and will work closely with the above Project 81.

Annual budget: IV-V

Time frame: 4 years

Contact: Miguel Delibes, Estación Biológica de Doñana, Apartado 1056, Avda. Maria Luisa s/n, 41013 Sevilla, Spain.

83. Increasing public awareness of the endangered status of the Iberian lynx in Spain*

Objective: To promote conservation of the Iberian lynx in Spain (and reduce inadvertent human-caused mortality) through a public awareness campaign.

Description: Human-caused mortality, particularly traps and snares set for rabbits, but also including illegal shooting and road kills, is high for the Iberian lynx in Spain (see Species Account), and can have serious adverse effects on small isolated populations. This project is developing public education campaigns directed at two audiences—hunters and school children—to promote awareness of the endangered status of the Iberian lynx and the importance of its conservation. Activities include production and distribution of posters, leaflets, pins, and stickers; travelling lectures; and a children's art competition with the lynx as the subject.

Annual budget: II

Time frame: 1 year

Contact: Sociedad Española para la Conservación y Estudio de los Mamíferos (SECEM), Depto. Biologia Animal, Universidad de Málaga, 29071 Mlaga, Spain.

Eurasian lynx (*L. lynx*): Category 2

84. Support for the Status and Conservation of the Alpine Lynx Population Project*

Objectives: To re-establish the lynx in the Alps through international cooperation by (1) defining the present distribution and status of the lynx in the Alps; (2) reviewing the reintroduction of the lynx into the Alps 20 years after the first releases; (3) agreeing on methods of monitoring the development of sub-populations; and (4) proposing internationally coordinated conservation measures where necessary.

Description: Lynx were eradicated in the Alps during the 19th century. The Alps are one of the last near-natural areas of central and western Europe, stretching from France through Switzerland and Italy to eastern Austria and Slovenia over an area of nearly 200,000 km^2. These mountains could sustain a population of more than 1,000 lynx, and could connect and support smaller potential populations in secondary mountain chains. Lynx have been reintroduced into the Alps several times since the 1970s (Austria, Germany, Italy, Slovenia, Switzerland) with mixed results. Most reintroduced populations have not been monitored. In recent years, heavy casualties due to illegal killing and road accidents have halted the expansion of at least the Swiss population. Inbreeding is also a potential threat. The long-term goal of the reintroductions must be to connect the sub-populations into a single Alpine meta-population. This can only be accomplished through international cooperation. This project is run by the Eurasian Lynx Group of the Cat Specialist Group, and is funded in part by the Swiss Federal Office of the Environment and WWF Switzerland.

Annual budget: I

Time frame: Ongoing

Contact: Urs Breitenmoser and Christine Breitenmoser-Würsten, Swiss Lynx Project, Villettengässli 4, CH-3074 Muri, Switzerland.

85. Spatial organization, population dynamics, and feeding ecology of the reintroduced lynx population in Slovenia*

Objective: To study the ecology and population dynamics of the reintroduced lynx population in Slovenia.

Description: The Slovenian lynx population has undergone remarkably rapid range expansion since six animals were reintroduced in 1973. The population has not been studied, and this radio-telemetry project will employ the same methodology used to study the reintroduced Swiss lynx populations. Four lynx have been radio-collared to date. The ecology of the lynx in Slovenia will provide important data on the lynx's relationship with other large carnivores, particularly the wolf and the brown bear, which are expanding their ranges in the Alps where lynx have been reintroduced. The researchers will emphasize re-establishing historic connectivity in European lynx populations through Austria, where nine lynx were released in 1977-1979, but a population was apparently not established.

Annual budget: III

Time frame: 3 years

Contact: Thomas Huber, Institut für Wildbiologie und Jagdwirtschaft, Universität für Bodenkunde, Peter-Jordan-Strasse 76, A-1190 Wien, Austria.

86. Preliminary assessment of lynx status in the Caucasus region*

Objective: To conduct a preliminary assessment of lynx distribution and status in the Caucasus mountains of Armenia, Azerbaijan, Georgia, and Russia.

Description: The Caucasus mountains are believed to be a significant reservoir of intraspecific diversity: these heavily spotted animals were once believed to be conspecific with the Iberian lynx (*Lynx pardinus*), as discussed in the Species Account. They are also believed to be very rare and threatened—a recent WWF survey of Georgia's Borzhom Nature Reserve, an important regional protected area for lynx, found no sign of lynx presence. This project will conduct further surveys in key areas to define current lynx status.

Annual budget: I-II

Time frame: 2 years

Contact: Jason Badrize, Institute of Zoology, 31 Chavchavadze Ave., GE 380 030 Tbilisi, Republic of Georgia.

87. Biology and ecology of the lynx in the lowland primeval forest of the Bialowieza Nature Reserve, Poland*

Objectives: To document (1) spatial organization, activity patterns and migration by lynxes through radio-telemetry; (2) the impact of lynx predation on ungulate populations; and to develop (3) a conservation plan for lynx in Poland.

Description: The Bialowieza lynx population is the last remaining native population of lynxes in lowland primeval

European forest. Indigenous lynx populations have not yet been studied through radio-telemetry. Preliminary studies suggest unusually high levels of predation on red deer. The ecology of the Bialowieza population will be intensively studied through radio-telemetry, snow tracking, recording of ungulate kills and surveys of ungulate prey density. At the same time, educational materials will be produced to help conserve lynx populations in other parts of Poland.

Annual budget: II

Time frame: 3 years

Contact: Henryk Okarma, Mammal Research Institute, 17-230 Bialowieza, Poland.

88. Ecology and status of lynx populations in Scandinavia*

Objectives: To study the ecology and status of lynx populations in northwestern Europe through radio-telemetry.

Description: The Scandinavian lynx populations are the largest in western Europe, but their ecology and limiting factors have not yet been studied with radio-telemetry. Findings of these projects, which focus on estimating national populations, mapping their distribution, and identifying limiting factors, will have important implications for hunting management in the region.

Annual budget: III

Annual budget: 5 years

Contact: Sweden: Tommy Krüger, Dept. of Zoology, University of Stockholm, Svante Arrhenius väg 14-16, S-106 91 Stockholm, Sweden. Norway: Tvor Kvam, Norsk Institutt for Naturforskning, Tungasletta 2, N-7005 Trondheim, Norway.

European wildcat (*F. silvestris, silvestris* group): Category 3

89. Status survey and taxonomic evaluation of the wildcats of the Mediterranean islands*

Objectives: To evaluate the conservation and taxonomic status of wildcat populations on selected Mediterranean islands.

Description: Wildcats occur on the nearly 100 islands off the European, African, and west Asian coasts, but their taxonomic status is not known. They are believed to be most closely related to the *lybica* group, but it has also been suggested that some populations have evolved from feral domestic cats originally introduced to the islands by humans. This project will address the following problems: (1) present occurrence and distribution; (2) past occurrence and/or way of colonization; (3) taxonomic and genetic status; (4) natural history; (5) population status; (6) conservation and management problems; and (7) conservation and management strategies. Preliminary work has begun in Greece, Sardinia, and Corsica. This project will be complementary to Projects 10, 15, and 45.

Annual budget: IV

Time frame: 5 years

Contact: Bernardino Ragni, Instituto de Zoologia, Facoltà di Scienze, Università degli Studi di Perugia, Via Elce di Sotto, Perugia 06100, Italy.

90. Status and distribution of the wildcat in France*

Objectives: To evaluate the status and distribution of wildcat populations in France.

Description: France is home to one of the largest wildcat populations in Europe. This project, sponsored in part by the Office National de la Chasse of the Ministère de l'Environnement, will conduct presence/absence surveys to complete a detailed population distribution map, and evaluate the degree of hybridization with domestic cats.

Annual budget: I

Time frame: 2 years

Contact: Philippe Stahl, Office National de la Chasse, Grange neuve, 01330 Villars les Dombes, France.

The Americas

Kodkod (*Oncifelis guigna*): Category 1

91. Natural history, distribution, and status of the kodkod*

Objectives: To conduct the first study of the behavior and ecology of the kodkod through radio-telemetry; to collect biological samples for genetic analysis; and to conduct presence/absence surveys in key parts of its range to map population distribution and evaluate species status.

Description: The kodkod has an unusually restricted range, and is moreover separated into two major population groups: the largest associated with temperate rain forest in Chile and Argentina, and the other with coastal shrubland in central Chile. The natural history study will be carried out in the moist temperate mixed forests of Argentina's Nahuel Huapi National Park, a habitat typical of the largest population group, and will greatly advance understanding of the species biology, ecology and status. Biological samples will be collected for genetic analysis to better evaluate taxonomic status, particularly with regard to Geoffroy's cat. Finally, the project will contact the Corporación Nacional Forestal (CONAF) in Chile to conduct presence/absence surveys for the kodkod in both major reserves and in modified habitats, such as farmland and logged areas, with priority going to central Chile. The project has support from the Delegación Técnica Regional Patagonia of the Administración de Parques Nacionales of Argentina (complete radio-telemetry equipment) and is partially sponsored by the Sociedad Naturalista Andino Patagónica.

Annual budget: II

Time frame: 2-3 years

Contact: Osvaldo Néstor Herrera, c/o Claudio Chehébar, Delegación Técnica, Regional Patagonia, Administración de Parques Nacionales, Intendencia del Parque Nacional Nahuel Huapi, 8400 San Carlos de Bariloche, Rio Negro, Argentina.

Andean mountain cat (*Oreailurus jacobitus*): Category 1

92. Natural history, distribution, and status of the Andean mountain cat

Objectives: To gather the first information on the behavior and ecology of the Andean mountain cat through radiotelemetry; to collect biological samples for genetic analysis; and to conduct presence/absence surveys in the high Andes to map population distribution and evaluate species status.

Description: The Andean mountain cat, with a restricted range in the high alpine zones of the Andes mountains of South America, is one of the least known cats in the world. There are few existing records by which to document the range of the Andean mountain cat. This project will conduct surveys in selected parts of the high Andes to examine: (1) species occurrence; (2) degree of population isolation; and (3) habitat and prey association variables. Data will also be gathered on the occurrence of sympatric cat species. If possible, biological samples will be gathered for morphological and genetic analysis. The survey will permit selection of an appropriate site for the natural history study component of the project. Baseline behavioral and ecological data will complement and complete the information gathered by the first component on species distribution and status.

Annual budget: II

Time frame: 3-4 years

Jaguar (*Panthera onca*): Category 2(A)

93. Jaguar and puma depredation of livestock in the Pantanal of Mato Grosso, Brazil*

Objectives: To examine cattle mortality on ranches in the Brazilian Pantanal, determine what percentage is attributable to large cats, and develop specific management recommendations for big cats in the region.

Description: The seasonally flooded inland Pantanal delta area, the largest of its kind in the world, protects an important population of jaguars, as well as pumas. Jaguar distribution has been mapped in the Pantanal (most occur outside of protected areas: Quigley and Crawshaw 1992), and the percentage of livestock in jaguar and puma diets living on one ranch has been quantified (Crawshaw and Quigley 1991 and in prep.). This study will complement the others by examining overall cattle mortality through monitoring of ranch records; accompanying ranch hands on patrols; cattle carcass collection; and by quantifying calf suvival by fitting 50-60 calves with radio collars equipped with mortality sensors. Jaguars and pumas will also be radio-collared. Data obtained on movement, activity and predation will be analyzed in relation to cattle management practices to evaluate the impact of these predators on ranch livestock. Results of the study will be used to develop a big cat conservation management plan for the region, suggesting alternative practices which may reduce economic losses resulting from depredation. The study area encompasses both a high-density cattle ranch and the adjacent 1,400 km^2 Pantanal National Park.

Annual budget: IV

Time frame: 3 years

Contact: Peter Crawshaw, IBAMA, Projeto Carnívoros, Parque Nacional do Iguaçu, C.P. 750, Foz do Iguaçu, Paraná 85851-970, Brazil.

94. Ecology of jaguars and other carnivores in the Brazilian cerrado*

Objective: To study, through radio-telemetry, the ecology of a carnivore community in the Brazilian cerrado.

Description: The cerrado (savannah woodland) is the second largest habitat type in Brazil (after tropical rain forest), but the ecology of the cats and other carnivores living there has never been studied. Emas National Park is the largest protected area (1,310 km^2) in the cerrado, and is potentially home to six felid species: jaguar, puma, margay, ocelot, pampas cat, and jaguarundi. This project will attempt to capture and radio-collar a representative sample of each species, along with other carnivores, and will compile the first scientific overview of the ecology of a cerrado carnivore community. Its results will aid assessment of species status over a large area of central Brazil, particularly significant for the jaguar.

Annual budget: III

Time frame: 5 years

Contact: Peter Crawshaw, IBAMA, Parque Nacional do Iguaçu, C.P. 750, Foz do Iguaçu, Paraná 85851-970, Brazil. Leandro Silveira, Depto. de Ciencias Biológicas e Biomédicas, Universidade Católica de Goiás, Avenida Universitária 1440, Setor Universitário, Goiania, Goiás 74210, Brazil.

95. Conservation of the jaguar in the tropical dry forests of Mexico*

Objectives: To study the natural history of a northern population of jaguars in tropical dry forest habitat; and to evaluate the potential of the proposed Chamela-Cuixmala Biosphere Reserve to support a viable jaguar population.

Description: Biosphere reserves are designed to preserve adequate areas to maintain viable poulations of plants and animals. It is often unknown if a biosphere reserve, such as the proposed Chamela-Cuixmala reserve in central coastal Mexico, is adequate for large carnivores. This area represents one of the northernmost jaguar populations, and this study will gather data and make recommendations necessary to ensure its viability. Jaguar ecology, movements, and spatial organization will be studied with the aid of radio-telemetry; jaguar and prey densities estimated in the reserve; and a conservation management plan will be produced.

Annual budget: V

Time frame: 3 years

Contact: John W. Laundre, Department of Biological Sciences, Idaho State University, Pocatello, ID 83209, U.S.A.

See also Project 6.

Oncilla (*Leopardus tigrinus*): Category 2

96. Natural history of the oncilla, margay, and ocelot

Objectives: To conduct a comparative study of the behavior and ecology of the *Leopardus* species in an area where they occur sympatrically.

Description: This project will be the first to study the natural history of the oncilla in any detail, and will also examine ecological niche partitioning with its close sympatric relatives, the margay and the ocelot. It should yield data that will help further understanding of the oncilla's distribution, especially association with lowland tropical rain forest in the Amazon basin (see Species Account and Project 97).

Annual budget: IV

Time frame: 4-5 years

97. Distribution of the oncilla

Objectives: To map the distribution of the oncilla in selected parts of its range.

Description: The oncilla's distribution is little known. It appears to be strongly associated with montane cloud forest, but has been recorded from other habitat types, including tropical dry forest, subtropical forest, and eucalyptus plantations. It appears to be absent from much of the lowland tropical rain forest of the Amazon basin, a stronghold for its close sympatric relatives, the ocelot and the margay. A Cat Specialist Group regional coordinator will oversee presence/absence surveys for the oncilla in selected parts of its range to clarify species distribution. Data on sympatric species occurrence will also be collected, and survey materials and techniques will be carefully designed to avoid confusion between the oncilla and the other small spotted cats, on which data will also be collected.

Annual budget: I-II

Time frame: 3 years

Margay (*Leopardus wiedi*): Category 3

See Projects 96 and 97 above for the oncilla.

Canada lynx (*Lynx canadensis*): Category 3

98. Long-term studies of the effects of harvest on northern Canada lynx populations*

Objective: To continue two long-term studies of the effects of fur harvesting on northern populations of Canada lynx.

Description: Two provincial government-sponsored projects are underway in northern Canada, the stronghold of the Canada lynx, to evaluate the effects of trapping on population dynamics. The Yukon study compares a protected population to a trapped population, with focus on the role played by natural refugia in population recovery. The study in the Northwest Territories monitors hare and lynx densities in an untrapped area. It has been pointed out that there have been no studies of the dynamics of a Canada lynx population throughout an entire 10-year hare-lynx cycle; both of these studies, underway for several years now, will fill this gap and greatly advance understanding of the unusual ecology of the Canada lynx. In addition, they will help to shape regulation of trapping in an area which constitutes the stronghold of Canada lynx range.

Annual budget: III

Time frame: 2-5 years

Contact: Brian Slough, Fish and Wildlife Branch, Yukon Dept. of Renewable Resources, Box 2703, Whitehorse, YT Y1A 2C6, Canada; Kim G. Poole, Wildlife Management Division, NWT Renewable Resources, Yellowknife, NWT X1A 2L9, Canada.

Geoffroy's cat (*Oncifelis geoffroyi*): Category 3

99. Natural history and distribution of Geoffroy's cat and the pampas cat in the Argentinian pampas grasslands

Objectives: To gather the first information on the behavior and ecology of these two sympatric cat species in the habitat type that makes up the majority of their ranges; to evaluate ecological niche partitioning between the two species; and to map population distribution.

Description: Pampas grasslands make up a large part of the ranges of both the pampas cat and Geoffroy's cat, but the natural history of these species has not been studied. For Geoffroy's cat, there has been one natural history study in the southernmost part of its range; for the pampas cat, none. This study will evaluate, through a radiotelemetry study and wider-ranging presence/absence surveys, ecological separation between the two species, and their response to cattle ranching and other forms of habitat modification. Recommendations for conservation of the small cats of the pampas will be made.

Annual budget: III

Time frame: 3-4 years

Puma (*Puma concolor*): Category 4(A)

100. Support for investigations into the presence of pumas in eastern North America*

Objective: To continue investigation into reports of puma occurrence in eastern North America.

Description: Pumas have been considered extinct in eastern North America for close to a century. However, a steady stream of observations points to either (1) remnant populations; (2) recent recolonizations; or (3) escapes from captivity. This project, in association with the Friends of the Eastern Panther and other local puma conservation groups, will undertake the following activities: (1) publication of a field guide to pumas and their sign; (2) publication of a bibliography on eastern pumas; (3) communication and investigation of future puma sightings. A conference on eastern pumas was held in 1994, and a newsletter is produced bi-annually.

Annual budget: II

Time frame: 2 years

Contact: Jay Tischendorf, American Ecological Research Institute, P.O. Box 380, Fort Collins, CO 80522, U.S.A.

101. Support for Proyecto Puma in Patagonia*

Objective: To continue the long-term study of the ecology of the puma in Chilean Patagonia.

Description: In cooperation with the Chilean Corporación Nacional Forestal (CONAF), Proyecto Puma has been running in Chile's Torres del Paine National Park for nearly a decade, and has gathered important data on the behavior and ecology of pumas in the southernmost part of their range. The pumas are well-habituated to humans, and park authorities are increasingly worried about potential harm to tourists. This will be one aspect of the future activities of the project. The other will be to quantify the impact of puma predation on guanacos, the major ungulate prey species of puma in the southern Andes.

Annual budget: III

Time frame: 3-5 years

Contact: William L. Franklin, Dept of Animal Ecology, 124 Science II, Iowa State University, Ames, IA 50011-3221, U.S.A.

102. Projeto Puma: conservation of the puma in a densely settled region of southern Brazil*

Objectives: To map the distribution of the puma in the southern Brazilian states of Rio Grande do Sul and Santa Catarina, and to work with farmers to develop techniques to limit livestock losses to pumas.

Description: Southern Brazil is relatively densely settled, and the jaguar has almost disappeared from this region. Pumas still exist in fragmented montane habitat, but persecution in response to livestock depredation could lead to their extirpation. The NGO, Projeto Puma, which is sponsored in part by the Brazilian government, Instituto Brasileiro de Meio Ambiente e dos Recursos Naturais Renovveis (IBAMA), is studying the behavior of pumas in this area, their response to habitat encroachment and human interference, and the extent and nature of livestock depredation incidents. The project is relevant to big cat conservation in settled areas. The first component, partly completed, is a short-term comparative study of predation rates between farms with different management techniques, which aims to identify the most important factors affecting livestock loss. The second component will be testing the effectiveness of various measures to reduce depredation, including wild prey population supplementation, different forms of herd management, and the use of nauseating substances on puma-killed livestock carcasses.

Annual budget: II-III

Time frame: 6 years

Contact: Marcello Mazzoli, Projeto Puma, Universidade Federal de Santa Catarina—UFSC, Campus Universitário, Laboratório de Mamiferos Aquáticos, Florianópolis 88015-600, Santa Catarina, Brazil.

103. Long-term study of puma ecology in southwestern Alberta, Canada*

Objective: To continue the long-term study of pumas in a major wilderness area of southwestern Canada, with emphasis on predator-prey dynamics, and quantifying the puma's prey requirements.

Description: Pumas have been studied in the Sheep River area of southwestern Alberta since 1981. Major prey species are annually censused by the Alberta Fish and Wildlife Division, and puma numbers and predation rates are estimated through daily monitoring of radio-collared individuals.

Annual budget: III

Time frame: Ongoing

Contact: Martin Jalkotzy and Ian Ross, Associated Resource Consultants (ARC), 2201 34th Street SW, Calgary T3E 2W2, Alberta, Canada.

See also Project 6.

Ocelot (*Leopardus pardalis*): Category 4

See Projects 96 and 97. No other specific projects suggested.

Bobcat (*Lynx rufus*): Category 4

104. Distribution and status of the bobcat and puma in the Mexican Sierras

Objectives: To map the distribution of bobcat and puma populations in selected areas of Mexico and assess species status.

Description: The dry scrub, oak, and pine forest habitats of the Mexican Sierras have suffered the highest degree of transformation and degradation relative to other habitat types, and dryland scrub habitat is under-represented in the system of protected areas (Flores-Villela and Fernandez 1989). Surveys will be carried out in selected areas to map the distribution of the bobcat and the puma in these habitat types, and assess the status of key populations. This area represents the southernmost part of bobcat range and, for pumas, links South and North American populations.

Annual budget: I-II

Time frame: 2 years

Pampas cat (*Oncifelis colocolo*): Category 4

105. Evaluation of the taxonomic status of the pampas cat*

Objectives: To determine, through morphological and genetic analysis, whether the "pampas cat" is actually more than one species.

Description: Results from the first component of this project, morphological analysis of nearly 80 pampas cat specimens from museums around the world, suggests that the pampas cat may be actually composed of three species (see Species Account). Genetic analysis is needed to test these results, which would obviously have important implications for species status and prioritization of conservation action.

Annual budget: III

Time frame: 2 years

Contact: Dr. Rosa García-Perea, Museo Nacional de Ciencias Naturales, José Gutiérrez Abascal 2, 28006 Madrid, Spain.

See also Projects 94 and 99 above. Additional data on natural history and distribution in the high Andes will be gathered by Project 92.

Jaguarundi (*Herpailurus yaguarondi*): Category 5

No specific projects suggested. Some data on natural history and distribution will be gathered in the course of surveys for sympatric cat species (Projects 94 and 97).

Appendix 1

Classically Described Cat Subspecies

Derived from Compilations by C. Groves and A. Shoemaker

Family Felidae, G. Fischer, 1817

Subfamily Acinonychinae Pocock, 1917

Acinonyx Brookes, 1828.

***Acinonyx jubatus* (Schreber, 1775). Cheetah.**

hecki Hilzheimer, 1913. Northwest Africa.
fearsoni Smith, 1834. East Africa. Probably includes *ngorongorensis* and *obergi* Hilzheimer, 1913; and *raineyi* and *velox* Heller, 1913.
jubatus Schreber, 1775. Southern Africa.
soemmerringi Fitzinger, 1855. Somalia and Eritrea to Lake Chad.
venaticus Griffith, 1821. Arabia to central India, now found only in Iran, includes *raddei* Hilzheimer, 1913.

Subfamily Felinae Fischer, 1817

Caracal Gray, 1843.

***Caracal caracal* (Schreber, 1776). Caracal.**

algirus Wagner, 1841. Maghreb region, Morocco to Algeria.
caracal Schreber, 1776. South Africa.
damarensis Roberts, 1926. Namibia.
limpopoensis Roberts, 1926. Northern Transvaal.
lucani Rochebrune, 1885. Grasslands of southeastern Gabon.
michaelis Heptner, 1945. Deserts of the Caspian Sea region, east to the Amur Darya River.
nubicus Fischer, 1829. East Africa, north to the Nubian Desert and west to Cameroon.
poecilotis Thomas and Hinton, 1921. Nigeria.
schmitzi Matschie, 1912. Palestine east to India.

Catopuma Severtzov, 1858.

***Catopuma badia* (Gray, 1874). Bornean bay cat.**
No subspecies described.

***Catopuma temmincki* (Vigors and Horsfield, 1827). Asiatic golden cat.**

dominicanorum Sclater, 1898. Southern China.
temmincki Vigors and Horsfield, 1827. Sumatra north to sub-Himalayan region. Probably there is more than one recognizable subspecies in this region.
tristis Milne-Edwards, 1872. Highlands of southwestern China, where the spotted form of the golden cat is most prominent.

Felis Linnaeus, 1758.

***Felis bieti* Milne-Edwards, 1892. Chinese mountain cat.**

The forms *chutuchta* Birula, 1917 and *vellerosa* Pocock, 1943, described from the Gobi Desert region, probably refer respectively to an Asian desert wildcat and a domestic cat (Groves 1980). No subspecies recognized.

***Felis chaus* Schreber, 1777. Jungle cat.**

affinis Gray, 1830. Sub-Himalayan region.
chaus Schreber, 1777. Jordan Valley and Mesopotamia north to the Caucasus Mountains region and east through the deserts of the Caspian and Aral seas. Includes *furax* de Winton, 1898 and *oxiana* Heptner, 1969.
fulvidina Thomas, 1928. Vietnam. Possibly includes Burma and Thailand, or these may represent an undescribed race.
kelaarti Pocock, 1939. Southern India and Sri Lanka.
kutas Pearson, 1832. Northern India and Pakistan, includes *prateri* Pocock, 1939.
nilotica de Winton, 1898. Lower Nile River valley, Egypt.

***Felis margarita* Loche, 1858. Sand cat.**

harrisoni Hemmer, Grubb and Groves, 1976. Arabia.

margarita Loche, 1858. Sahara, includes *meinertzhageni* and *airensis* Pocock 1938.
scheffeli Hemmer, 1974. Pakistan, perhaps west to Iran.
thinobia Ognev, 1927. Deserts east of the Caspian sea.

***Felis nigripes* Burchell, 1824. Black-footed cat.**
nigripes Burchell, 1824. Namibia through the Kalahari to the northern Transvaal.
thomasi Shortridge, 1931. Eastern Cape Province, South Africa.

***Felis silvestris* Schreber, 1775. Wildcat.**

***lybica* group**
brockmani Pocock, 1944. Somalia.
cafra Desmarest, 1822. South Africa, Zimbabwe, southern Mozambique.
foxi Pocock, 1944. Bush country from Senegal to Lake Chad.
griselda Thomas, 1926. Kalahari region to southern Angola.
iraki Cheesman, 1920. Arabian desert regions.
gordoni Harrison, 1968. Batinah coast of Oman.
lybica Forster, 1780. Desert regions of North Africa to Sudan and northern Niger; probably includes *haussa* Thomas and Hinton 1920, *lowei* and *lynesi* Pocock, 1944.
mellandi Schwann, 1904. South-Central Africa (southern Zaire, Zambia, Malawi, northern Mozambique).
nesterovi Birula, 1916. Mesopotamian region to south-western Iran.
ocreata Gmelin, 1791. Ethiopian highlands.
pyrrhus Pocock, 1944. Northern Angola and south-western Zaire.
sarda Lataste, 1885. Coastal Maghreb region (Morocco and Algeria) and Sardinia (probably introduced).
tristrami Pocock, 1944. Palestine and Red Sea coast of Arabia.
ugandae Schwann, 1904. East Africa, includes *nandae* and *taitae* Heller, 1913.

***ornata* group**
caudata Gray, 1874. Deserts east of the Caspian Sea to the Tian Shan Mountains, includes *matschiei* and *murgabensis* Zukowsky, 1914.
ornata Gray, 1830. India. Probably east through Iran.
shawiana Blanford, 1876. Xinjiang and Mongolia, includes *chutuchta* Birula, 1917 and *kozlovi* Satunin, 1905.

***silvestris* group**
caucasica Satunin, 1905. Caucasus mountains and Turkey.
grampia Miller, 1907. Britain, now restricted to Scotland.
silvestris Schreber, 1775. Europe, east to the Carpathian mountains and the river Dnieper north of the Black Sea.

Named island subspecies include: *cretensis* Haltenorth, 1953 (Crete); *jordansi* Schwarz, 1930 (Balearic islands); and *reyi* Lavauden, 1929 (Corsica).

Herpailurus Severtzov, 1858.

***Herpailurus yaguarondi* Lacépède, 1809. Jaguarundi.**
ameghinoi Holmberg, 1898. Western Argentina, south-east to Río Negro province.
cacomitli Berlandier, 1859. South Texas and neighboring regions of northeastern Mexico.
eyra Fischer, 1814. Southern Brazil through Paraguay to northern Argentina.
fossata Mearns, 1901. Honduras to southern Mexico.
melantho Thomas, 1914. Andean valleys of Peru and upper Amazonia, Brazil.
panamensis Allen, 1904. Ecuador through western Colombia to Costa Rica.
tolteca Thomas, 1898. Sinaloa, Mexico to Arizona.
yagouaroundi Geoffroy, 1803. Amazon basin of Brazil north to the Guiana highlands.

Leopardus Gray, 1842.

***Leopardus pardalis* (Linnaeus, 1758). Ocelot.**
aequatorialis Mearns, 1902. Northern Andes.
albescens Pucheran, 1855. Northeastern Mexico to Texas and, historically, Lousiana.
maripensis J.A. Allen, 1904. Venezuela east to Guiana highlands.
mitis Cuvier, 1820. Southern Brazil through Paraguay to northern Argentina.
nelsoni Goldman, 1925. Western Mexico from Oaxaca to Sinaloa.
pardalis Linnaeus, 1758. Southern Mexico through Central America, includes *mearnsi* J.A. Allen, 1904.
pseudopardalis Boitard, 1842. Northern Colombia and western Venzuela.
pusaeus Thomas, 1914. Coastal Ecuador and perhaps Peru.
sonoriensis Goldman, 1925. Northwestern Mexico to Arizona.
steinbachi Pocock, 1941. Bolivian highlands.

***Leopardus tigrinus* (Schreber, 1775). Oncilla.**
oncilla Thomas, 1903. Costa Rica.
pardinoides Gray, 1867. Northern Andes.
tigrinus Schreber, 1775. Northeastern Brazil and Guyanas.

***Leopardus wiedi* (Schinz, 1821). Margay.**
amazonicus Cabrera, 1917. Upper Amazon.
boliviae Pocock, 1941. Andean slopes.
cooperi Goldman, 1943. Southeastern Texas and adjoining regions of Mexico.
glauculus Thomas, 1903. Dry country of Mexico; probably includes *oaxacensis* Nelson and Goldman, 1931.
nicaraguae J.A.Allen, 1919. Central America; probably includes *salvinius* Pocock, 1941.
vigens Thomas, 1904. Northeastern Brazil to the Guyanas.
wiedi Schinz, 1821. Southeastern Brazil to northeastern Argentina.
yucatanicus Nelson and Goldman, 1931. Rainforest regions of Mexico.

Leptailurus Severtzov, 1858.

***Leptailurus serval* (Schreber, 1776). Serval.**
Many, probably too many, subspecies have been described. Weigel (1961) points out that there is a general division between a dark, fine-spotted type (*brachyurus* and *lipostictus*) and a lighter, large-spotted type (most of the rest), with *beirae, togoensis,* and *pococki* being somewhat intermediate.

brachyurus Wagner, 1841. Sierra Leone. May include *pococki* Cabrera, 1910 (Senegal) and *togoensis* Matschie, 1893 (Dahomey gap).
constantinus Forster, 1780. Northern Morocco and Algeria.
hindei Wroughton, 1910. Kenya, east of the Rift Valley. May include *ferrari* de Beaux, 1924 (southern Somalia).
liptostictus Pocock, 1907. Uganda, Zaire, and northern Angola moist forest. May include *faradjius* Allen, 1924 (northeastern Zaire); *kivuensis* Lönnberg, 1919 (Lake Kivu region) and *kempi* Wroughton, 1910 (Kenya west of the Rift Valley).
phillipsi Allen, 1914. Ethiopian highlands west to Lake Chad.
serval Schreber, 1776. Southern Zaire and Tanzania, south to Cape Province. Probably includes *beirae* Wroughton, 1910 (Beira district, Mozambique); *hamiltoni* Roberts, 1931 (northern Transvaal); *ingridi* Lundholm, 1955 (Zimbabwe); *limpopoensis* Roberts, 1926 (Botswana and western Transvaal); *lonnbergi* Cabrera, 1910, *mababiensis* Roberts, 1932 and *niger* Lönnberg, 1897 (southern Angola).
tanae Pocock, 1944. Dry zone of Ethiopia, Eritrea and northern Somalia.

Lynx Kerr, 1792.

***Lynx canadensis* Kerr, 1792. Canada lynx.**
canadensis Kerr, 1792. Mainland northern U.S. and Canada.
subsolanus Bangs, 1897. Newfoundland island.

***Lynx lynx* (Linnaeus, 1758). Eurasian lynx.**
carpathicus Kratochvíl and Stollmann, 1963. Carpathian Mountains west to Bulgaria and Greece.
dinniki Satunin, 1915. Caucasus Mountains south to Turkey and northern Iran.
isabellinus Blyth, 1847. Kashmir and Tibet north to the Tian Shan and Altai mountain ranges in Xinjiang and Mongolia.
kozlovi Fetisov, 1950. Central Siberia, from the Yenisei River to Lake Baikal.
lynx Linnaeus, 1758. Northern and western Europe east to the Yenisei River in Russia.
neglectus Stroganov, 1962. Russian Far East, Korea, and northeastern China (Manchuria); includes *stroganovi* Heptner, 1969.
wrangeli Ognev, 1928. Eastern Siberia, south to the Stanovoy mountains.

***Lynx pardinus* (Temminck, 1827). Iberian lynx.**
No subspecies described.

***Lynx rufus* (Schreber, 1776). Bobcat.**
After Hall (1981), with comments by Samson (1979). Read (1981), based on differences between over 950 bobcat skulls from the southcentral U.S., considers that too many subspecies were recognized by Hall, pointing to the lack of geographic barriers between them.

baileyi Merriam, 1890. Southwestern arid zone from California to western Texas and Utah, and south to Durango, Mexico.
californicus Mearns, 1897. Nevada to central and southern California.
escuinapae Allen, 1903. Central Mexico. Samson (1979) suggests that the subspecies is invalid, being very similar to *californicus* and *texensis;* however, he had a small sample size and did find it to differ from *baileyi,* the subspecies directly to the north.
fasciatus Rafinesque, 1817. Coastal forests from southwestern British Columbia to northern California.
floridanus Rafinesque, 1817. Southeastern U.S.
gigas Bangs, 1897. Maine and adjacent southeastern Canada, including Nova Scotia.
pallescens Merriam, 1899. Rocky mountains from British Columbia to New Mexico.
peninsularis Thomas, 1898. Baja California, Mexico.

rufus Schreber, 1776. Northeast and central U.S. Samson (1979) recommends that this taxa be split into northeastern and central plains subspecies.
superiorensis Peterson and Downing, 1952. Southeastern Manitoba to Wisconsin and Minnesota.
texensis, Allen, 1895. Western Lousiana through eastern Texas to northeastern Mexico.

Oncifelis Severtzov, 1858.

Oncifelis colocolo (Molina, 1782). Pampas cat.
braccatus Cope, 1899. Mato Grosso to northern Argentina and the southernmost tip of Brazil. The pampas cat's range in Brazil extends through the center and into the northeastern region, but specimens have not been analyzed taxonomically (Silveira in press).
budini Pocock, 1941. Salta highlands in northwestern Argentina.
colocolo Molina, 1782. Central Chile.
crespoi Cabrera, 1957. Salta lowlands in northwestern Argentina.
garleppi Matschie, 1912. Andes in Peru, Ecuador and Bolivia.
muñoai Ximénez, 1961. Uruguay.
pajeros Desmarest, 1816. Pampas grasslands from Buenos Aires to southernmost Argentina and Chile.
thomasi Lönnberg, 1913. Ecuador.

García-Perea (1994) considers the pampas cat to consist of three species, further separated into the following subspecies:

Lynchailurus pajeros (Desmarest, 1816). Distributed from the eastern slopes of the Andes in Ecuador south through lowland habitats to Patagonia. Subspecies: *budini, crespoi, crucinaus* Thomas, 1901 (Patagonia), *garleppi, pajeros, steinbachi* Pocock 1941 (Bolivia), and *thomasi*.

Lynchailurus braccatus (Cope, 1899). Distributed through humid, warm grass- and shrubland in Brazil, Paraguay and Ecuador. Subspecies: *braccatus* and *muñoai*.

Lynchailurus colocolo (Molina, 1782). Distributed as two separate populations in Chile. Subspecies: *colocolo* (sub-tropical forests at middle elevations in central Chile) and *wolffsohni* (García-Perea 1994) on the western slope of the Andes in northern Chile.

Oncifelis geoffroyi (d'Orbigny and Gervais, 1844). Geoffroy's cat.
after Ximénez (1975)
euxanthus Pocock, 1940. Bolivian highlands.
geoffroyi d'Orbigny and Gervais, 1844. Pampas grasslands from Buenos Aires south to Patagonia.
paraguae Pocock, 1940. Southern Paraguay, southernmost Brazil, Uruguay and northern Argentina.
salinarum Thomas, 1903. Chaco region.

Oncifelis guigna (Molina, 1782). Kodkod.
guigna Molina, 1782. Southern Chile and Argentina.
tigrillo Schinz, 1844. Central Chile, includes *molinae* Osgood, 1943.

Oreailurus Cabrera, 1940.

Oreailurus jacobitus (Cornalia, 1865). Andean mountain cat.
No subspecies described.

Otocolobus Brandt, 1842.

Otocolobus manul (Pallas, 1776). Manul.
ferrugineus Ognev, 1928. Kazakhstan south to Iran and Pakistan, including the lowlands south of the Caucasus and west of the Caspian Sea.
manul Pallas, 1776. Lake Baikal region south through Mongolia to Gansu province, China.
nigripectus Hodgson, 1842. Kashmir east to Nepal, through the Tibetan highlands and east to Sichuan.

Prionailurus Severtzov, 1858.

Prionailurus bengalensis (Kerr, 1792). Leopard cat.
after Yu and Wozencraft (in press)
alleni Sody, 1949. Hainan Island, off the coast of southern China. Possibly not distinct from *chinensis*.
bengalensis Kerr, 1792. Indian and Indochinese regions (including China's Yunnan province), and Malay peninsula.
borneoensis Brongersma, 1935. Borneo. Possibly not distinct from *sumatranus*.
chinensis Gray, 1837. China, except for northeast, and Taiwan.
euptilurus Elliot, 1871. Manchurian region, Korea and Russian Far East (includes Japanese Tsushima islands off the coast of South Korea). Heptner (1971) considered this taxa a separate species, but there are no geographic barriers which would serve to isolate it.

horsfieldi Gray, 1842. Sub-Himalayan region east of the Indus River.
iriomotensis Imaizumi, 1967. Iriomote Island, Japan. Some authorities recognize the Iriomote cat as a separate species, *Mayailurus* or *Prionailurus iriomotensis*.
javanensis Desmarest, 1816. Java and Bali.
sumatranus Horsfield, 1821. Sumatra and Nias islands.
trevelyni Pocock, 1939. Kashmir.

Forms from the Philippine islands remain undescribed. Rabor (1986) has suggested that the leopard cats of Panay, Negros, and Cebu, which are separated from the Sunda Shelf by deep water channels, may be a different and endemic subspecies of the Philippines in comparison with the population found on Palawan, which would be expected to have a closer relationship to Indonesian island populations (C. Groves, W. Oliver *in litt.* 1993).

***Prionailurus planiceps* (Vigors and Horsfield, 1827). Flat-headed cat.**
No subspecies described. Specimens from continental southeast Asia, Sumatra, and Borneo are slightly different, but the material is limited.

***Prionailurus rubiginosus* (I. Geoffroy Saint-Hilaire, 1831). Rusty-spotted cat.**
phillipsi Pocock, 1939. Wet zone of southwestern Sri Lanka.
koladivinus Deraniyagala, 1956. Dry zone of Sri Lanka.
rubiginosus I. Geoffroy St.-Hilaire, 1831. Southern India. Whether specimens from northwestern India are of this subspecies is unknown, but there is a skin in the British Museum of Natural History labelled Pakistan, which is extremely different.

***Prionailurus viverrinus* (Bennett, 1833). Fishing cat.**
rizophoreus Sody, 1936. Java.
viverrinus Bennett, 1833. Sri Lanka, India, continental southeast Asia and Sumatra.

Profelis Severtzov, 1858.

***Profelis aurata* (Temminck, 1827). African golden cat.**
aurata Temminck, 1827. West Africa.
celidogaster Temminck, 1827. Central Africa, east into Kenya.

Van Mensch and Van Bree (1969) classed all populations between the Cross (Nigeria) and Zaire (Congo) rivers as intermediate between the two subspecies.

Puma Jardine, 1834.

***Puma concolor* (Linnaeus, 1771). Puma.**
Puma subspecies are presently being investigated from a genetic perspective at the laboratory of S.J. O'Brien.

acrocodia Goldman, 1943. Chaco region of Paraguay and Boliva.
anthonyi Nelson and Goldman, 1931. Rain forest of southern Venezuela.
borbensis Nelson and Goldman, 1933. Central Amazonia.
californicus May, 1896. California (non-desert, except far north). Probably includes *aztecus* Merriam, 1901 (New Mexico and Arizona south to Jalisco); *browni* Merriam, 1903 (arid southwestern U.S. to Chihuahua); and *improcera* Philipps, 1912 (Baja California, Mexico).
bangsi Merriam, 1901. Northern Andes (Colombia, Ecuador, and Peru). Probably includes *soderstromi* Lönnberg, 1913 (northern Ecuador and southern Colombia).
concolor Linnaeus, 1771. The Guyanas.
coryi Bangs, 1899. Florida and Lousiana, now restricted to southern Florida.
costaricensis Merriam, 1901. Nicaragua to Panama. Possibly includes *mayensis* Nelson and Goldman, 1929 (Yucatan peninsula of Mexico south to Honduras).
cougar Kerr, 1792. Northeastern U.S. and eastern Canada. Extinct, or nearly so.
greeni Nelson and Goldman, 1929. Eastern Brazil.
hippolestes Merriam, 1897. Rocky mountains in Wyoming to Idaho and New Mexico. Probably includes *missoulensis* Goldman, 1943 (North Dakota and Yellowstone National Park to Cassiar Mountains of British Columbia and southwestern Saskatchewan).
hudsoni Cabrera, 1957. Pampas grasslands of Argentina.
kaibabensis Nelson and Goldman, 1931. Kaibab plateau, Arizona.
oregonensis Rafinesque, 1832. Coastal forests of British Columbia south to northern California. Probably includes *olympus* Merriam, 1897 (Olympic mountains, Washington) and *vancouverensis* Nelson and Goldman, 1932 (Vancouver Island, British Columbia).
osgoodi Nelson and Goldman, 1929. Bolivian Andes.
pearsoni Thomas, 1901. Type locality Santa Cruz province, about 70 miles inland off the coast, southern Argentina. Synonym probably *patagonicus* Merriam, 1901. Type locality Lake Pueyrredon, in the Altiplano on the border with Chile, Santa Cruz province, southern Argentina (Currier 1983).

puma Molina, 1782. Chile across the high cordillera to western Argentina. According to Cabrera (1961), probably includes *araucanus* Osgood, 1943 (central Chile); *cabrerae* Pocock, 1940 (west and central Argentina); *incarum* Nelson and Goldman, 1929 (southern Peru); and *punensis* Housse, 1950 (Tarapaca, Chile).
schorgeri Jackson, 1955. Upper Mississippi River area.
stanleyana Goldman, 1938. Texas and northeastern Mexico. S. O'Brien (in CBSG 1991) notes that this taxa is "genetically similar" to *coryi*.

Subfamily Pantherinae Pocock, 1917

Neofelis Gray, 1867.

***Neofelis nebulosa* (Griffith, 1821). Clouded leopard.**
brachyurus Swinhoe, 1862. Taiwan. Described as a subspecies based upon short tail length, but Pocock (1939) found that this measurement is not a consistent criterion. Possibly extinct.
diardi Cuvier, 1823. Malay peninsula, Sumatra and Borneo.
macrosceloides Hodgson, 1853. Sub-Himalayan zone from Nepal to Myanmar.
nebulosa Griffith, 1821. Indochinese region and southern China.

Panthera Oken, 1816.

***Panthera leo* (Linnaeus, 1758). Lion.**
after Hemmer (1974b).
azandica Allen, 1924. Northeastern Zaire.
bleyenberghi Lönnberg, 1914. Shaba and Kasai woodland savannah regions of southern Zaire, and presumably also neighboring parts of Zambia and Angola.
krugeri Roberts, 1929. Kalahari region east to the Transvaal and Natal regions of South Africa.
leo Linnaeus, 1758. Coastal woodlands of Morocco through Tunisia. Extinct.
melanochaita H. Smith, 1842. Cape region, South Africa. Extinct.
nubica de Blainville, 1843. Northeast and east Africa. Includes *massaica* Neumann, 1900; *somaliensis* Noack, 1891; and *roosevelti* Heller, 1913.
persica Meyer, 1826. From Iraq to central India in the 19th century; now restricted to Gir Forest, India.
senegalensis Meyer, 1826. West Africa, east to the Central African Republic.

O'Brien *et al.* (1987b) analyzed samples from captive African lions and from wild lions of Tanzania's Serengeti National Park and South Africa's Kruger National Park, and suggested that they were of sufficient genetic similarity to warrant subsummation into a single African race, *P. leo leo*.

***Panthera onca* (Linnaeus, 1758). Jaguar.**
After Pocock (1939b) and Seymour (1987) and in need of revision, as Pocock's arrangement was based on very few specimens and weakly marked distinctions.

arizonensis Goldman, 1932. Originally from Sonora, Mexico to southwestern U.S.; now extinct in the U.S.
centralis Mearns, 1901. Nicaragua to Colombia.
goldmani Mearns, 1901. Yucatan peninsula of Mexico south to Belize and northern Honduras.
hernandesi Gray, 1857. Tehuantepec and Sinaloa, Mexico northeast to Lousiana (now extinct in the U.S.).
onca Linnaeus, 1758. Amazon and Orinoco rain forest.
palustris Ameghino, 1888. Southern Brazil south through Uruguay to the Río Negro in Argentina; now restricted to a few locations in southern Brazil.
paraguensis Hollister, 1914. Paraguay.
peruviana de Blainville, 1843. Coastal regions of Peru and Ecuador.
veraecrucis Nelson and Goldman, 1933. Tabasco to central Texas.

***Panthera pardus* (Linnaeus, 1758). Leopard.**
adersi Pocock, 1932. Zanzibar (extinct).
adusta Pocock, 1927. Ethiopian highlands.
ciscaucasica Satunin, 1914. Caucasus mountains. According to Heptner and Sludskii (1972), the range is through northern Iran to Afghanistan, and *saxicolor* is a synonym.
dathei Zukowsky, 1964. Southern and central Iran, of dubious validity.
delacouri Pocock, 1930. Southern China to Malay peninsula; *sinensis* is a synonym.
fusca Meyer, 1794. Indian sub-continent.
kotiya Deraniyagala, 1956. Sri Lanka.
japonensis Gray, 1862. North-central China; probably includes *bedfordi* Pocock, 1930; *chinensis* Gray, 1867; and *fontanieri* A.M. Edwards, 1867.
jarvisi Pocock, 1932. Sinai peninsula.
leopardus Schreber, 1777. Rain forests of west and central Africa; probably includes *ituriensis* J.A. Allen, 1924.
melanotica Günther, 1775. Southern Africa; *puella* and *shortridgei* Pocock, 1932 are probably synonyms.
melas G. Cuvier, 1809. Java.

nanopardus Thomas, 1904. Somali arid zone; *brockmani* Pocock, 1932 is a synonym, and the taxa probably includes *antinori* de Beauz, 1923 (Eritrea).
nimr Hemprich and Ehrenberg, 1833. Arabian peninsula to southern Israel.
orientalis Schlegel, 1857. Russian Far East, Korea, and northeastern China; includes *villosa* Bonhote, 1903.
panthera Schreber, 1777. Coastal woodlands of Morocco through Tunisia.
pardus Linnaeus, 1758. Sudan and northeastern Zaire; *chui* Heller, 1913 (southern Sudan and Uganda) is probably a synonym.
pernigra Hodgson, 1863. Kashmir through Nepal to southwestern Tibet and Sichuan; synonyms include *millardi* Pocock, 1930.
reichenowi Cabrera, 1918. Savannas of Cameroon.
ruwenzorii Camerano, 1906. Ruwenzori and Virunga mountains of Zaire, Rwanda, and Burundi.
saxicolor Pocock, 1927. Northern Iran and southern Turkmenia east to Afghanistan.
sindica Pocock, 1930. Southeastern Afghanistan through western and southern Pakistan.
suahelica Neumann, 1900. East Africa, from Mozambique north to Kenya.
tulliana Valenciennes, 1856. Turkey.

Miththapala (1992) analyzed subspeciation in the leopard in terms of genetics. She suggests subsuming all African races into *pardus*; all populations on the Indian sub-continent into *fusca* (i.e., including *pernigra*); and all central Asian races into *saxicolor*. However, only the African samples were considered to be sufficiently representative. She found the Sri Lankan leopard *kotiya* to be well differentiated. Sample sizes were either too small or inappropriate (coming from captive animals which were in some cases deliberately inbred or of uncertain origin) to produce conclusive results for *delacouri*, *japonensis*, *melas*, and *orientalis*. She recommends that her findings be further evaluated by analysis of pelage.

***Panthera tigris* (Linnaeus, 1758). Tiger.**
after Mazák (1979). Genetics are being re-analyzed at the laboratory of S. O'Brien.
altaica Temminck, 1844. Russian Far East, North Korea, and northeastern China (possibly extirpated from the latter two countries); formerly occasionally ranged west to Mongolia and Lake Baikal.
amoyensis Hilzheimer, 1905. South-central China, now restricted to a few locations in southern China.
balica Schwarz, 1912. Bali (extinct).
corbetti Mazák, 1968. Indochinese region north to Yunnan province, China, and south to the Malay peninsula.
sondaica Temminck, 1844. Java (extinct).
sumatrae Pocock, 1929. Sumatra.
tigris Linnaeus, 1758. Indian sub-continent.
virgata Illiger, 1815. Dry river valleys of the Takla Makan, western slopes of the Tianshan mountains, Amudarya and Syrdarya river valleys, shores of the Caspian sea, Elburz mountains, eastern Turkey, Tigris and Euphrates river valleys. Extinct.

Pardofelis Severtzov, 1858.

***Pardofelis marmorata* (Martin, 1837). Marbled cat.**
charltoni Gray, 1846. Sub-Himalayan region, from Nepal to Myanmar.
marmorata Martin, 1837. Continental southeast Asia, Sumatra and Borneo. Insular and Malay specimens are, as Pocock pointed out, grey-brown rather than ochraceous like those from the Indochinese region, and subspecific differentiation is probably warranted. Moreover, differences between the populations of Peninsular Malaysia, Sumatra, and Borneo may also be significant enough to warrant subspecific separation.

Uncia Gray, 1854.

***Uncia uncia* (Schreber, 1775). Snow leopard.**
after Stroganov (1962)
uncia Schreber, 1775. Northern populations: Central Asia northeast to Mongolia and Russia.
uncioides Horsfield, 1855. Southern populations: Tibet, western China, and the Himalayas.

Analysis of subspeciation in the snow leopard is long overdue; many authorities have suggested that the naturally fragmented nature of its habitat may have led to significant differences between populations.

Appendix 2

Scientific Postmortem: A Protocol for Collection of Data and Specimens

by Andrew C. Kitchener, Steven McOrist, and Robert K. Wayne

There is a wide range of important biological information that can be obtained from a dead or tranquilized cat. This protocol is exhaustive, but can be adapted to the needs of any study. Whenever an opportunity presents itself, specimens should be preserved for taxonomic studies. Other information would add considerably to our knowledge of the basic biology of many species.

1. External Features

Record the following:

a. **Color of soft parts:** iris, nose, pads, insides of ears.

b. **Coloration and markings of skin:** take notes, or color photographs, of dorsal, ventral, and lateral aspects of body, and close-up of face against a standard background.

c. **Mammae:** if female, note number and position of mammae, and whether lactating.

d. **Weight:** if possible, weigh the whole animal. N.B. Subtract weight of stomach contents (see below), if these are likely to be a significant proportion of total weight.

e. **Measurements:** take the following measurements (see Fig. 1):

   i. *Total length (mm):* Lay the animal on its back to ensure the vertebral column is fully straight and the tip of the nose is in a straight line with the back and the tip of the tail. Never include fur at the tip of the tail.

   ii. *Tail length (mm):* From base of tail dorsally to fleshy tip of tail. Never include fur at the tip of the tail. It helps to move the tail through 90° to the body, in order to locate the base of the tail.

   iii. *Hind foot length (mm):* From ankle to tip of toes, excluding claws and fur. In the U.S., this measurement includes to the tip of the claws, which is not relevant for most felids. You may wish to measure hind foot length by both methods, where appropriate.

   iv. *Ear length (mm):* From notch in base of ear to tip of fleshy part of ear flap. Exclude fur or tufts.

f. **Teeth:** Note number and type, and any damage or decay, etc., especially if it is not possible to save skull (see below), or if examining a tranquilized cat.

g. **External parasites:** Examine fur for these and store in 70% alcohol.

2. Specimen Preparation

a. **Labelling:** All specimens should be labelled. We recommend aluminum tags, on which a number can be scratched, or embossing type (e.g., Dymo). These can both be wired on to any skins or skeletal material that are prepared. The numbers can then be cross-referenced with data in field notebooks. It is recommended that a second copy be made of this data, in case of accidental loss.

b. **Scavengers:** Watch out for scavengers, whether they be mammalian, avian, or insect, especially when hanging specimens out to dry. Many valuable specimens have been lost to scavengers.

c. **Skins:** If you have time, skin out the specimen, working in fine salt to the newly exposed surface, and also externally around the ears, eyes, and pads. When fully skinned, clean off excess flesh and fat, and rub in salt. If possible, let the skin dry in the sun. When dry, roll it up and store it somewhere safe and dry.

   In humid habitats where drying may not be possible, put the skin in a formic acid solution (8 cm^3 of 90%

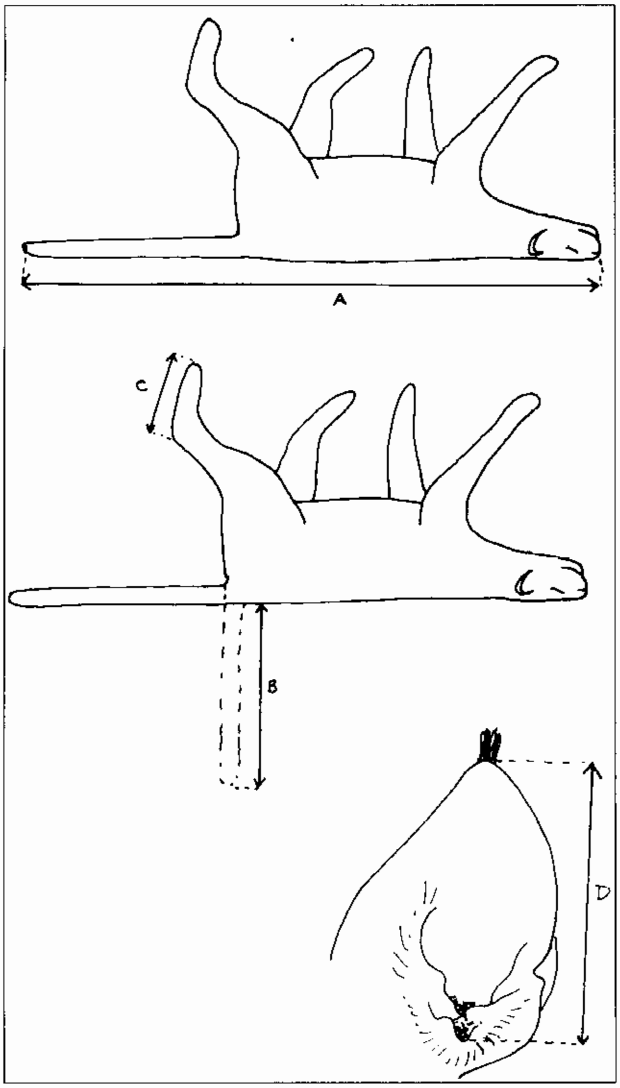


Figure 1. Postmortem measurements.
A = total length in mm; B = tail length in mm; C = hind foot length in mm; D = ear length in mm.

formic acid per liter of water, plus 100 g of salt per liter of water). When travelling, the solution can be drained off and the skins put in plastic bags or dried out before leaving. Put them in the freezer on arrival.

If desperate, store whole specimen in 70% alcohol or even methylated spirit. Use syringe to inject alcohol into body cavity, or eviscerate specimen. Never use formalin to preserve skins or skeletal material.

d. **Skeletal material:** Save at least the skull and if possible all of the skeleton. Disarticulate limbs and skull from specimen and remove soft tissues and rub salt over surfaces. Remove brain with forceps. Let bones dry in the sun if possible. Store in sealed tins. The worst that can happen is that the skeleton can get a bit smelly.

e. **Where to send specimens:** Send specimens to local universities and museums. If possible, make arrangements with institutions for opportunistic acquisition of material with respect to arranging import/export licenses, health licenses, etc. The key to the best use of any specimen is planning before any field work is started.

Obviously, only rarely will there be time to get all the information and specimens outlined above. Those items in bold lettering are key data and samples which are required as a minimum.

3. Internal examination

The purpose of a scientific post mortem is to collect information on biological parameters such as diet, reproductive status, etc., as well as to determine causes of morbidity and mortality by noting pathological features (i.e., those that differ from normal).

To this end, all major organ systems (cardiovascular, respiratory, alimentary, urogenital, and hemolymphatic) should be examined thoroughly. Data and samples should be examined from a wide range of tissues so that post mortem investigations are not limited to the one or two obvious features that may first strike the observer. Consultation with local veterinary laboratory services would ensure evaluation of most pathological samples. Thick slices of all major organs and portions of the gastrointestinal tract should be immersed in 10% buffered formalin. Stomach contents, internal parasites, intestinal length and reproductive organs should be carefully examined (see below).

Where viruses are suspected at a post mortem, samples of fresh spleen, liver, and lymph nodes should be collected and stored chilled at 0° C before being sent to a virus laboratory. Virus transport medium is available at some centers. Blood sampling (see below) of a representative sample of a population of living cats for virus serology represents a further effective means of monitoring for the presence of viruses within a population.

a. **Stomach contents:** Examine and weigh stomach contents. If closer examination is needed, store contents in 70% alcohol or methylated spirits. Remember to label. Collect any endoparasites in gut, and store in 70% alcohol or 10% buffered formalin.

b. **Other internal parasites:** These should be noted and counted at each site within the body. Representative samples should be taken and preserved in 70% alcohol.

c. **Intestinal length:** For *Felis silvestris,* to aid determination of hybridization, measure intestinal length from pyloric to anal sphincter in a straight line (see European wildcat species account).

d. **Other internal parasites:** Store uterus and gonads in 10% buffered formalin, 70% alcohol, or methylated spirits.

4. Genetic samples

a. Tissue samples from dead cats:

i. Place half-dollar size piece (50 g, 1-2 cm diameter) of heart, tongue, skeletal muscle, kidney, liver (in order of preference) or any other tissue in a zip-lock plastic bag. Label and freeze as soon as possible. If you want to take only one sample, heart or skeletal muscle is best. For liquid nitrogen storage wrap samples in foil or place in cryo-safe freeze vials.

or

ii. If there is no access to refrigeration, chop up samples into 1 mm pieces and place in a container with preservative. The following formula is preferred: 100 mm tris pH. 8.0, 100 mm EDTA, 2% SDS (Sodium Dodecyl Sulfate), mixed thoroughly. This formula can be obtained from R. Wayne at the address below, who will send solution or dry reagents measured for 500 ml volume of DH20. These reagents are also available from most university laboratories. If this preservative is not available, 90% alcohol can be used, although it is not as good.

Remember: any tissue that was once living can be a source of DNA. New techniques allow geneticists to obtain potentially useful material from bone, skin, hair, feces, even if the material is several years old and decayed. Don't throw anything away if it may be important!

b. Blood samples from live cats:

i. If you are routinely trapping cats for radio collaring or tagging, it is possible to take blood samples for DNA and other blood analyses. Remember to record measurements, weight, and take photographs as described above. After tranquilizing the cat, take 5-10 cm^3 of blood by superficial vasopuncture with an appropriate needle or syringe. Blood should be immediately passed slowly into vacutained glass tubes containing EDTA (purple top) and mixed for 2 to 5 minutes to prevent clotting.

ii. Blood should be withdrawn from a glass tube with a plastic pipette, and approximately 1 cm^3 placed into 5-10 separate plastic Eppendorf tubes. Each tube should be carefully labelled.

iii. Three to eight of these tubes should be centrifuged at 1,500 rpm or greater for 10 minutes. The top layer of plasma can be removed from each tube with a plastic pipette and placed in a fresh labelled Eppendorf tube. These four tubes (two of plasma, two of cell pellets) should be sealed and stored frozen. This last step can be delayed for up to 48 hours, if the Eppendorf tubes are kept cool (not frozen).

iv. For field biologists without refrigeration, 5-10 ml of whole blood can be placed in equal volume of the following preservative solution: 100 mm tris pH. 8.0, 100 mm EDTA, 2% SDS (Sodium Dodecyl Sulfate), mixed thoroughly. This is the least desirable form of preservation.

v. The whole blood tubes (see step iii) can be used for DNA analysis and the remaining tubes for virus serology, biochemical analysis, etc.

The authors' institutions will gladly accept biological specimens.

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Appendix 3

Scientific Names of Species Mentioned in the Text
(in alphabetical order by common name)

Common Name	Scientific Name
Addax	*Addax nasomaculatus*
Agouti	*Dasyprocta variegata*
Andean fox	*Dusicyon culpaeus*
Arabian red-legged partridge	*Alectorus melanocephala*
Argali	*Ovis ammon*
Argus pheasant	*Argusianus argus*
Armadillo	Dasypodidae
Asiatic ibex	*Capra ibex sibirica*
Asiatic red sheep	*Ovis orientalis*
Asiatic wild ass/kiang	*Equus kiang*
Bamboo rat	*Rhizomys sinense*
Banded crake	*Porzana fusca*
Big-eared climbing rat	*Ototylomys phyllotis*
Bighorn sheep	*Ovis canadensis*
Blackbuck	*Antilope cervicapra*
Black koorhan	*Eupodotis afra*
Black rat	*Rattus rattus*
Blue sheep/bharal	*Pseudois nayaur*
Brown-eared bulbul	*Hypsipetes amaurotis*
Buffalo	*Syncerus caffer*
Camel	*Camelus dromedarius*
Cane mice	*Zygodontomys*
Cape fur seal	*Arctocephalus pusillus*
Cape hare	*Lepus capensis*
Capuchin monkeys	*Cebus* spp.
Capybara	*Hydrochaeris hydrochaeris*
Caribou, reindeer	*Rangifer tarandus*
Cavy	*Galea spixi*
Chamois	*Rupicapra rupicapra*
Characid fish	Characidae
Chevrotains	Tragulidae
Chinkara	*Gazella benetti*
Chital	*Axis axis*
Chukor partridge	*Alectorus chukor*
Common duiker	*Sylvicapra grimmia*
Cotton rats	*Sigmodon* spp.
Cottontail rabbits	*Sylvivagus* spp.
Coypu	*Myocastor coypus*
Dall sheep	*Ovis dalli*
Dik-dik	*Madoqua kirki*
Dorcas gazelle	*Gazella dorcas*
Dung beetles	Scarabaeinae
Eland	*Taurotragus oryx*
Elephant, African	*Loxodonta africana*
Elephant, Asian	*Elephas maximus*
Elk/Wapiti	*Cervus elaphas*
European hare	*Lepus europaeus*
European rabbit	*Oryctolagus cuniculus*
Fallow deer	*Dama dama*
Gaur, seladang	*Bos gaurus*
Gemsbok	*Oryx gazella*
Gerbils	*Gerbillus/Meriones* spp.
Gerenuk	*Litocranius walleri*
Giant panda	*Ailuropoda melanoleuca*
Gibbons	*Hylobates* spp.
Goral	*Nemorhaedus goral*
Great gerbil	*Rhombomys opimus*
Grey fox	*Dusicyon griseus*
Grey jungle fowl	*Gallus sonnerati*
Guanaco	*Lama guanicoe*
Guinea pigs	*Cavia* spp.
Guinea fowl	*Numida meleagris*
Hamster	*Phodopus* spp.
Hartebeest	*Alcelaphus* spp.
Harvester termite	*Hodotermes mossambicus*
Hog deer	*Axis porcinus*
Ibex	*Capra ibex*
Impala	*Aepyceros melampus*
Iriomote dwarf hog	*Sus scrofa riukinanas*
Jerboas	Dipodidae
Kangaroo rats	*Dipodomys* spp.
Kishinone skink	*Eumecas kiskinovi*
Kob	*Kobus kob*
Kudu, greater	*Tragelaphus strepsiceros*
Kudu, lesser	*Tragelaphus imberbis*
Land tortoises	*Geochelone* spp.
Lesser anteaters	*Tamuanda* spp.
Markhor	*Capra falconeri*
Marmosets	Callitrichidae
Marmots	*Marmota* spp.
Marsh rat	*Holichilus brasiliensi*
Mole rats	*Myospalax* spp.
Moose	*Alces alces*
Mouflon	*Ovis orientalis*
Mountain beaver	*Aplodontia rufa*
Mountain chinchilla	*Chinchilla brevicaudata*

Common Name	Scientific Name
Mountain reedbuck	*Redunca fulvorufula*
Mountain viscachas	*Lagidium* spp.
Mouse deer	*Tragulus* spp.
Mouse opossum	*Marmosa* spp.
Muntjac/barking deer	*Muntiacus* spp.
Musk deer	*Moscus* spp.
Nile grass rat	*Arvicanthis niloticus*
Nilgai	*Boselaphus tragocamelus*
Opossum	Didelphidae
Oribi	*Orebia ourebi*
Pangolin, African	*Manis* spp.
Oryx	*Oryx leucoryx*
Paca	*Agouti paca*
Peccaries	*Tayassu* spp.
Penguin (Patagonia spp.)	*Eudyptes* spp./*Spheniscus magellanicus*
Pig-tailed macaque	*Macaca nemestrima*
Pikas	*Ochotona* spp.
Porcupine, Indian	*Hystrix indica*
Porcupine, North American	*Erethizon dorsatum*
Porcupine, prehensile-tailed	*Coendou prehensilis*
Proboscis monkey	*Nasalis lavatus*
Pronghorn	*Antilocapra americana*
Puku	*Kobus vardoni*
Red brocket deer	*Mazama americana*
Red deer	*Cervus elaphas*
Red duiker	*Cephalophus nigrifrons*
Red hartebeest	*Alcelaphus buselaphus*
Reindeer, caribou	*Rangifer tarandus*
Rhino, black	*Diceros bicornis*
Rhino, white	*Ceratotherium simum*
Rice rat	*Oryzomys* spp.
River turtle	*Podocnemis unifilis*
Roan antelope	*Hippotragus equinus*

Common Name	Scientific Name
Rock hyraxes	*Procaviidae* spp.
Roe deer	*Cervus capreolus*
Ryuku flying fox	*Pteropus dasymallus*
Sable antelope	*Hippotragus niger*
Sambar	*Cervus unicolor*
Sand fox	*Vulpes rüppelli*
Snowcocks	*Tetraegallus* spp.
Snowshoe hare	*Lepus americanus*
Spiny pocket rats	*Heteromys* spp.
Spiny rats	*Proechimys* spp.
Springbok	*Antidorcas marsupialis*
Spring hare	*Pedetes capensis*
Squirrels	*Sciurus* spp.
Squirrel monkeys	*Saimiri* spp.
Striped hyaena	*Hyaena hyaena*
Susliks	*Spermophilus* spp.
Tapir	*Tapirus* spp.
Thomson's gazelle	*Gazella thomsoni*
Three-toed sloth	*Bradypus tridactylus*
Tolai hare	*Lepus capensis tolai*
Tree hyrax	*Dendrohyrax*
Tsama melon	*Citrullus lanatus*
Tufted deer	*Elaphodus cephalophus*
Vlei (swamp) rats	*Otomys* spp.
Warthog	*Phacochoerus aethiopicus*
Waterbuck	*Kobus ellipsiprymnus*
White-tailed deer	*Odocoileus virginianus*
White-tailed pine vole	*Pitymys leucurus*
Wild pig	*Sus scrofa*
Wildebeest	*Connochaetes* spp.
Wolf	*Canis lupus*
Wood rats	*Neotoma* spp.
Yak	*Bos grunniens*
Zebra	*Equus* spp.

Appendix 4

Species-Habitat Associations

This Appendix contains the species-habitat associations which were used to rank cat species vulnerability and assess global habitat status and protected area coverage with respect to cat conservation (Part II, Chapter 1). The Habitat chapter describes how species associations were assigned. When reading through this Appendix, reference should also be made to Figures 2a-f and Tables 1-2, 4, 8, and 11 in the Habitat chapter. These figures map the global habitat types of Olson *et al.* (1983); provide a definition of each type; list the number of species associated with each type; indicate rate of change in the geographic area of each type since 1980; and list percentage of range area protected for each cat species.

This Appendix is divided into four sections. The first section lists the species associated with each habitat type. The second section contains the same information organized differently: habitat associations by species. Section 3 describes the methodology for calculating species range size (for vulnerability ranking), while the fourth section describes the methodology for estimating percentage of species range that is protected.

Readers should correspond with the Chairman of the Cat Specialist Group to correct any errors in species-habitat association, and thus improve its application as a conservation tool.

Section 1. Species Association by Habitat Type

Species codes are used rather than full scientific names. The code consists of the first three letters of the specific name (e.g., par = *Panthera pardus*, leopard). Two other species names also begin with these letters, so their codes are: pdl (*Leopardus pardalis*, ocelot) and pdn *Lynx pardinus*, Iberian lynx). Similarly, tig is *Panthera tigris* (tiger) and tgn *Leopardus tigrinus* (oncilla); mar is *Felis margarita* (sand cat) and mma *Pardofelis marmorata* (marbled cat). Species are listed by species code in alphabetic, rather than generic, order.

Degree of Species Association by Habitat Type

Strong	Significant	Marginal
Major forest and woodland (1 and 2)		
aur, bad, ben, can, car, cha, con, geo, gui, jub, leo, lyn, mma, neb, onc, par, pdl, pdn, pla, rub, ruf, ser, sil, tem, tig, tgn, viv, wie, yag.	col.	bie, unc.
1. Closed forest and woodland		
aur, bad, ben, can, con, gui, leo, lyn, mma, neb, onc, par, pdl, pla, ser, tem, tig, viv, wie.	car, cha, geo, rub, ruf, sil, tgn, yag.	bie, col, jub, pdn, unc.
Taiga and other conifer		
can, con, lyn.	ben, par, ruf, tig.	bie, pdn, sil, tem, unc.

Strong	Significant	Marginal
1a. Main and southern taiga		
can, lyn.		unc.
1b. Other conifer		
can, con, lyn.	ben, par, ruf, tig.	bie, pdn, sil, tem, unc.
Mid-latitude broad-leaved and mixed forest		
ben, gui, lyn.	con, geo, neb, par, ruf,, ser, sil, tem, tig.	can, car, cha, col, pdl, pdn, unc, yag.
1c. Temperate broad-leaved forest		
	ben, geo, lyn, par, ruf, sil.	cha, col, con, neb, tem, tig.
1d. Mixed woods		
ben, gui, lyn.	con, neb, par, ruf, ser, tem, tig	can, car, cha, col, pdl, pdn, sil, unc, yag.
Main tropical/subtropical broad-leaved forest		
aur, bad, ben, cha, con, leo, mma, neb, onc, par, pdl, pla, ser, tem, tig, viv, wie	car, rub, sil, tgn, yag.	jub.
1e. Broad-leaved humid forest		
aur, bad, ben, con, mma, neb, onc, par, pdl, pla, tig, tem, viv, wie.	cha, tgn, yag.	
1f. Tropical dry forest and woodland		
cha, leo, par, ser, tem, tig, viv.	ben, car, con, mma, neb, pdl, rub, sil, yag.	jub, onc, tgn, wie.
2. Open or interrupted woodland		
car, geo, jub, leo, onc, par, pdl, pdn, rub, ruf, ser, sil, tgn, yag.	aur, bad, ben, can, cha, col, con, gui, lyn, mma, neb, pla, tem, tig, viv, wie.	
2a. Tropical savanna and woodland		
car, leo, onc, par, pdl, ser, sil, yag.	aur, con, jub, rub, wie.	cha, col, geo, ruf, viv.
2b. Tropical montane complexes		
tgn	aur, bad, neb, ser, tem, tig.	ben, car, cha, col, con, mma, par, pdl, wie, yag.
2c. Other dry woods/scrub/grass complexes		
car, geo, jub, pdn, rub, yag.	cha, col, con, gui, leo, onc, par, pdl, ruf, sil.	ben, ser.
2d. Northern or maritime taiga		
	can, lyn.	

Strong	Significant	Marginal
2e. Second growth woods and field mosaics		
ruf, sil.	ben, can, cha, col, geo, lyn, mma, rub, par, pla, ser, tem, tgn, viv, yag.	aur, car, con, jub, leo, neb, onc, pdl, pdn, tig, wie.
3. Settled areas: cropped, residential, commercial and associated marginal lands		
	ben, cha, geo, rub, ser, viv.	can, car, col, con, gui, jub, lyn, ruf, par, sil, yag.
3a. Paddyland		
	ben, cha, rub, viv.	par.
3b. Towns, farms and other irrigated dryland row crops		
	cha, geo, rub, ser.	ben, can, car, col, con, gui, jub, lyn, ruf, par, sil, yag.
4. Grass and shrub complexes: low vegetation with few or no trees		
bie, car, cha, col, con, geo, jub, man, nig, par, pdn, ruf, sil, yag.	jac, leo, pdl, rub.	ben, can, gui, lyn, mar, neb, onc, ser, tem, tig, unc.
4a. Grassland or shrubland		
bie, car, cha, col, con, geo, jub, man, nig, par, pdn, ruf, sil, yag.	jac, leo, pdl, rub.	ben, gui, lyn, mar, neb, onc, ser, tem, tig, unc.
4b. Cold grass or stunted woody complex		
man.		bie, can, lyn, unc.
5. Tundra, desert and semi-desert		
car, col, geo, jac, man, mar, nig, sil, unc.	bie, con, jub, leo, par, ruf.	can, cha, lyn.
5a. Tundra		
jac, unc.	bie.	can, col, con, lyn, man, par.
Desert and semi-desert		
car, col, geo, man, mar, nig, sil.	con, jub, leo, par, ruf.	bie, cha, lyn, unc.
5c. Cool semi-desert scrub		
col, geo, man.	con.	lyn, ruf, sil, unc.
5d. Sand desert		
mar.	car, nig, sil.	jub, leo, man, par.
5e. Other desert and semi-desert		
car, mar, nig, sil.	jub, leo, man, par, ruf.	bie, cha, con, lyn.
6. Major wetlands		
cha, onc, pla, ser, tig, viv.	pdn.	aur, ben, con, neb, pdl, ruf, yag.

Section 2. Habitat Association by Species

Habitat types are abbreviated by alphanumeric code; see previous section for key.

Taxa		Degree of Habitat Association: Strong	Significant	Marginal
A. jubatus	Sub-Saharan Africa	2c, 4a	2a, 5e	1f, 2e, 3b, 5d
	N. Africa-SW Asia	4a, 5e	2c, 5d	
	Global	2c, 4a	2a, 5e	1f, 2e, 3b, 5d
C. caracal	Sub-Saharan Africa	2a, 2c, 4a	1f, 5e	2b, 2e, 3b, 5d
	N. Africa-SW Asia	4a, 5e	2a, 2c, 5d	1d, 2e, 3b
	Global	2a, 2c, 4a, 5e	1f, 5d	1d, 2b, 2e, 3b
C. badia		1e	2b	
C. temmincki		1e, 1f	1d, 2b, 2e	1b, 1c, 4a
F. bieti		4a	5a	1b, 4b, 5e
F. chaus	N. Africa-SW Asia	4a, 6	2c, 2e, 3b	1c, 1d, 5e
	Tropical Asia	1f, 6	1e, 2e, 3a, 3b	1c, 1d, 2a, 2b, 4a
	Global	1f, 4a, 6	1e, 2c, 2e, 3a, 3b	1c, 1d, 2a, 2b, 5e
F. margarita		5d, 5e		4a
F. nigripes		4a, 5e	5d	
F. silvestris	*lybica*	2a, 4a, 5e	1f, 2c, 5d	1d, 2e, 3b
	ornata	4a, 5e	5d	2c, 2e, 3b, 5c
	silvestris	1c, 2e	2c, 4a	1b, 3b
	Global	2a, 2e, 4a, 5e	1c, 1f, 2c, 5d	1b, 1d, 3b, 5c
H. yaguarondi		2a, 2c, 4a	1e, 1f, 2e	1d, 2b, 3b, 6
L. pardalis		1e, 2a	1f, 2c, 4a	1d, 2b, 2e, 6
L. tigrinus		2b	1e, 2e	1f
L. wiedii		1e	2a	1f, 2b, 2e
L. serval	Sub-Saharan Africa	1f, 2a, 6	2b, 2e, 3b	2c, 4a
	N. Africa-SW Asia	1d	2c, 4a	
	Global	1f, 2a, 6	1d, 2b, 2e, 3b	2c, 4a
L. canadensis		1a, 1b	2d, 2e	1d, 3b, 4b, 5a
L. lynx	Asia	1a, 1b, 1d	1c, 2d, 2e	4a, 4b, 5a, 5c, 5e
	Europe	1a, 1b, 1d	1c, 2e	3b
	Global	1a, 1b, 1d	1c, 2d, 2e	3b, 4a, 4b, 5a, 5c, 5e
L. pardinus		2c, 4a	6	1b, 1d, 2e

Taxa		Degree of Habitat Association		
		Strong	Significant	Marginal
L. rufus		2e, 4a	1b, 1c, 1d, 2c, 5e	2a, 3b, 5c, 6
O. colocolo		4a, 5c	2c, 2e	1c, 1d, 2a, 2b, 3b, 5a
O. guigna		1d	2c	3b, 4a
O. geoffroyi		2c, 4a, 5c	1c, 2e, 3b	2a
O. jacobitus		5a	4a	
O. manul		4a, 4b, 5c	5c	5a, 5d
P. bengalensis		1d, 1e	1b, 1c, 1f, 2c, 3a	2b, 2c, 3b, 4a, 6
P. planiceps		1e, 6	2e	
P. rubiginosus		2c	1f, 2a, 2c, 3a, 3b, 4a	
P. viverrinus		1e, 1f, 6	2c, 3a	2a
P. aurata		1e	2a, 2b	2e, 6
P. concolor		1b, 1e, 4a	1d, 1f, 2a, 2c, 5c	1c, 2b, 2e, 3b, 5a, 5e, 6
N. nebulosa		1e	1d, 1f, 2b	1c, 2e, 4a, 6
P. leo		1f, 2a	2c, 4a, 5c	2e, 5d
P. onca		1e, 2a, 6	2c	1f, 2e, 4a
P. pardus	Sub-Saharan Africa	1e, 1f, 2a	2c, 2e, 4a, 5e	2b, 3b, 5d
	N. Africa-SW Asia	4a	1c, 2a, 2c, 5e	1d, 2e, 5d
	Tropical Asia	1e, 1f	1b, 1d, 2b, 2e	1c, 2a, 3a, 3b, 5a
	Global	1e, 1f, 2a, 4a	1b, 1c, 1d, 2c, 2e,	2b, 3a, 3b, 5a, 5d, 5e
P. tigris		1e, 1f, 6	1b, 1d, 2b	1c, 2e, 4a
P. marmorata		1e	1f, 2e	2b
U. uncia		5a		1a, 1b, 1d, 4a, 4b, 5c

Section 3. Methodology Used to Calculate Species Range Area

Approximate range sizes of the cat species were presented in Box 1 in the Introduction to the Species Accounts (Part I). Species range area was calculated by adding up the geographic coverage of all habitat types within each species' contemporary range with which the species is strongly or significantly (not marginally) associated. Figures for geographic coverage by habitat type were obtained from two sources. The primary source was Table 18.2 in WCMC's *Global Biodiversity* (WCMC 1992), which combines the habitat types of Olson *et al.* (1983) into eight major groupings (Major forest, Interrupted woods, Crop and settlements, Grass and shrub, Polar and alpine, Desert and semi-desert, Major wetlands, and Other coastal aquatic). The habitat type "Other coastal aquatic" was not used for species-habitat association or species range area calculation because it includes the area taken up by lakes and beaches. The WCMC table lists percentage area occupied by these eight habitat groupings for each country (Saudi Arabia, for example, is listed as 62% Desert and semi-desert). The percentage area was converted to km^2 using data on country area given in *The Times Atlas of the World* (8th edn., 1990). Area was expressed in millions of km^2, rounded off to three decimal places (e.g., Saudi Arabia, with a total land area of 2.4 million km^2, has 1.490 million km^2 of desert and semi-desert).

In many cases, a reduction factor was applied to account for either: (1) species occurrence in only a portion of a country's habitat type, or; (2) species occurrence in only a portion of WCMC's (1992) habitat type groupings. Examples of the first type include the tiger's occurrence in only a tiny portion of Russia's coniferous forest (1b), and the sand cat's apparent absence from much of Egypt. An example of the second type is the leopard's scattered, patchy distribution in the sub-Saharan African Sahel region (a portion of habitat type 2c). These three examples also illustrate the three ways in which reduction factors were applied. In the case of the tiger, pixels of coniferous forest were counted on the habitat map and multiplied by 3,000 km^2. In the second case, the sand cat, the geographic area of desert and semi-desert for Egypt was reduced by 80%. In the leopard's case, the total area of habitat type 2c for sub-Saharan Africa was reduced by 33% to eliminate the Sahel region. There is a high potential for error in applying reduction factors, as they were calculated by visual comparison of species range maps to the habitat types, taking into account patchy distribution or rarity as described in the species accounts.

Only one other source was used for data on habitat area, and then only for a few species. WCMC (1992) combines tropical forest area for Java, Sumatra, and Borneo with data for other Indonesian islands and Peninsular Malaysia. When separate habitat area data was required, figures from the *IUCN Conservation Atlas of Tropical Forests: Asia and the Pacific* (Collins *et al.* 1991) were used.

In the few cases where good data available on the area of species contemporary range (snow leopard [Fox 1995] and Iberian lynx [Rodríguez and Delibes 1992]), our range area estimates have turned out to be too high. The overestimate was by a factor of 0.25 in the case of the snow leopard, and by 5.3 in the case of the Iberian lynx. Error in the case of the Iberian lynx is unavoidable as the methodology used here lacks resolution on a small scale. The actual range of the Iberian lynx is estimated at only 14,000 km^2, and the lynx is restricted largely to the south of the Iberian peninsula in over 100 isolated sub-populations. Nonetheless, the estimate served its purpose by qualifying the geographic range of the Iberian lynx for the smallest category, "Restricted."

The purpose of the exercise was to compare species range on a relative, rather than absolute scale. While it is hoped that the bias for other species is closer to that of the snow leopard range calculation, this cannot be determined with the data at hand. The error arises from many sources, including: (1) the methodology of Olson *et al.* (1983), which assigns a 3,050 km^2 pixel to the habitat type predominating within it, regardless of the other types of habitat it contains; (2) errors in geographic area calculations which may have arisen when WCMC (1992) compiled their table; (3) errors in assigning species-habitat associations and degree of association; (4) errors in application of reduction factors; and (5) failure of the species range maps to represent actual species range. Given the likelihood of error, our estimates of species range area should not be treated as definitive. They represent a first attempt to apply a standard methodology to estimation of cat species range, and are useful for developing a more strategic approach to cat conservation. It is hoped that they serve as a stimulus for further work.

Section 4. Methodology Used to Calculate Species Occurrence in Protected Areas

Species occurrence in protected areas is presented in Part II, Chapter 1, Table 11. WCMC (1992: Table 29.5) calculated the number and total geographic area of protected areas occurring within the biogeographic provinces of the world, as defined by Udvardy (1975). Udvardy (1975) delineated 195 biogeographic provinces, which do not correspond to the habitat types defined by Olson *et al.* (1983). However, from Udvardy's (1975) map, it is possible to identify the biogeographic provinces which fall within cat species ranges. The assumption was made that all protected areas falling within a species range contained the species. The approximate total number of protected areas which potentially contain cat species, and the approximate total geographic area covered by these protected areas, were obtained by adding up the numbers for each biogeographic province falling within a species range. If the range of a particular cat species included only a portion of an Udvardy biogeographic province, a corresponding reduction factor was applied to both the number and total area of the protected areas of the biogeographic province. The percentage of protected species range was obtained by dividing the total area protected by the total estimated species range size.

Appendix 5

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Appendix 6

The International Fur Trade Federation

A Statement

The International Fur Trade Federation (IFTF) represents national fur trade associations in 28 countries. They include virtually every country where fur is either seriously produced or traded. Countries in which fur is produced and traded which do not belong to IFTF include India, Nepal, and most South American countries.

The Federation's activities in the field of conservation date from the early 1970s when, concerned about the decline in the flow of leopard skins from producing countries, the IFTF introduced a voluntary ban on the handling of several cat and other species. Since then, the Federation has helped to finance a number IUCN and CITES surveys into the status of various fur-bearing animals. In addition, in association with the government of Canada, IFTF has helped to fund important research into improved trapping methods.

In accordance with its 1985 constitution, IFTF is concerned at all times with the conservation of fur-bearing animals, and supports CITES and the strict observance of its regulations. IFTF members are bound by this constitution, and may be liable to expulsion if they fail to act against any member of their own association proven to have violated CITES regulations.

IFTF stands solidly behind practical measures to improve the enforcement of CITES. It condemns and dissociates itself from incidents of unscrupulous traders selling threatened species to tourists and indulging in illegal activities. It is as much in the trade's interest as in CITES' interests that such practices be stopped.

The legitimate international trade has no interest in handling CITES-listed species unless they are available in commercial quantities under proper, regulated controls.

In sum, the trade's position is straightforward—it believes in strictly regulating trade in any species scientifically proven to be threatened, but expects to trade in the sustainable yield of any species which is not threatened, in accordance with the sustainable use principles laid down in the documents, *World Conservation Strategy* and *Caring for the Earth,* published by IUCN—The World Conservation Union, UNEP—the United Nations Environment Programme, and WWF—World Wide Fund for Nature.

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