Measuring the Impacts of Ecotourism on Animal Populations: A Case Study of Tikal National Park, Guatemala

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ABSTRACT
Nature tourism has great potential for negatively impacting animals as tourists seek out rare and spectacular species. Ecotourism-induced stresses on animals may result in changes in population densities, species composition, and community structure. Tikal National Park is visited extensively by tourists, most of whom are concentrated around the Mayan ruins. Potential impacts of tourism in Tikal were evaluated by comparing the population densities of select species of mammals and birds in two regions of the park, with and without tourist traffic. Densities were estimated using visual line transects and distance sampling methods. Trends show the impact of ecotourism is species specific, with some species increasing in density, some decreasing, and others unaffected. An evaluation of the limitations and assumptions of the methods used provides a framework for consideration of the results. Given the potential negative impact of tourists on animals, national parks should develop management strategies to minimize these impacts, such as concentrating tourists in already disturbed areas.

INTRODUCTION

In recent years, ecotourism has been touted as a solution for conservation and development woes because of its ability to protect threatened biodiversity while providing economic growth for people living in and around protected areas (Wells and Brandon 1992). The tourism industry has been growing rapidly along with an increasing interest in nature-based tourism or ecotourism. Ecotourism is defined by the IUCN—The World Conservation Union—as "environmentally responsible travel and visitation to relatively undisturbed natural areas, in order to enjoy, study, and appreciate nature (and any accompanying cultural features...), that promotes conservation, (and) has low visitor impact" (Ceballos-Lascurain 1993). While protected natural areas are increasing in popularity as vacation destinations, little information exists on tourism's impacts on protected areas (Boo 1990). With a rapid increase in ecotourism, it is important to determine the impacts which are occurring despite the difficulty of quantifying these changes.

Animals in protected areas may face stress due to ecotourism. Nature tourism has great potential for negative impacts on animals, as tourists seek out rare or spectacular species—often during sensitive times, such as breeding or nesting (Knight and Cole 1995). Previous studies have found that tourists cause negative impacts on the movement, foraging, and reproductive behavior of large felids and

ursids, the nesting behavior of sea turtles, and the distribution of waterfowl (Kumpumula 1979, Western 1986, Boo 1990, Muthee 1992, Van Schaik, personal communication 1995, Jacobson and Figueroa Lopez 1994, Klein et al. 1995).

Where human traffic is frequent, some species withdraw, some change behavior, and still others may become habituated to human presence (Van Schaik, personal communication 1995, Griffiths and Van Schaik 1993). As animals become habituated to humans, they may use areas in which tourists are present as "escape valves" from predators, which avoid tourist destinations and human hunters.

Long-term studies of primates often report increases in population size, probably due to decreased predation associated with the presence of human researchers (Griffiths and Van Schaik 1993). Ecotourism is likely to have a similar impact, particularly where animals are deliberately habituated to human presence for tourist observation (Griffiths and Van Schaik 1993). However, the long term effects of human presence may mimic those of hunting, changing community structure due to differences in a species' vulnerability or attractivity as prey (Griffiths and Van Schaik 1993).

If conservation is the yardstick by which we measure the success of ecotourism, then it is important to determine and measure the impacts of tourists on animal populations; however, they are difficult to quantify.

Ecotourism's impacts may result in abnormally high or low population densities of some species in tourist areas and can potentially lead to ecological change through population increases in the habituated or unaffected species, possibly altering the densities of their competitors or prey (Griffiths and Van Schaik 1993). There also may be long-term consequences on the floristic makeup of an area due to altered patterns of seed dispersal and predation (Griffiths and Van Schaik 1993; Terborgh 1995 personal communication). These changes may have effects on the composition and functioning of the entire ecosystem.

Guatemala's protected areas are important for protecting its biodiversity as much of the country's forested areas are threatened by human encroachment (Van Schaik et al., in press). Tourism in Guatemala, though still in its infancy, is the country's fastest growing industry with revenues more than quadrupling since 1986 (Harris and Ritz 1993). However, the impacts of tourism on Guatemala's National Parks are unknown.

Tikal National Park, comprising approximately 562 km^2, is located in El Petén department of northern Guatemala and is the core of the Mayan Biosphere Reserve. It is considered one of the true wonders of the world, both for its Mayan ruins and the lush rainforest which surrounds the ruins. Tikal is visited extensively by tourists, most of whom are concentrated in the area around the Mayan ruins. What impact is the presence of tourists having on the fauna of Tikal?

The goal of this project is to compare animal population densities in two different regions of Tikal National Park to identify variations which may possibly be explained by tourism pressures. Population densities of select species were estimated for two areas of the park: 1) an area frequented by tourists and 2) a little disturbed tract of forest.

METHODS

Densities of mammals and large ground birds were estimated using line transect surveys and distance sampling methods (Buckland et al. 1993). Surveys were conducted in two regions within Tikal National Park, Guatemala. The study site was located in an area frequented by tourists (e.g., along trails around the ruins). The control area was located in a little-disturbed tract of forest in which the Peregrine Fund's Maya Project had cut transects for previous research. Nine transects were sampled in each area. They were controlled for forest type and canopy cover to the greatest degree possible. The areas were described by degree of tourist use, forest type, and additional confounding variables.

The presence of tourists may alter the species composition and population densities of some animals, which in turn may have effects on the composition and functioning of the ecosystem.

The transects in the study area followed existing trails in the Mayan ruins and ranged in length from 0.5 to 1.1 km. The transects were located in upland forested areas around the periphery of the ruins and avoided the open areas of the central plaza.

The control site was located approximately four kilometers from the ruins and consisted of two groups of four transects each plus a ninth along part of an abandoned logging road. The two groups were located two kilometers apart and one kilometer from the road. The transects were located primarily in upland forest and ranged in length from 0.6 to 1.65 km.

The species to be surveyed were determined based on input from the Center for Tropical Conservation at Duke University and the Peregrine Fund's Maya Project (Table 1, page 52).

Line transect surveys were conducted during the morning and evening by slowly walking along the transects (a given direction and distance) and recording animal sightings (Buckland et al. 1993, Burnham et al. 1980, Emmons 1984). Surveys in the ruins were conducted by a single observer. A guide was present during observation in the control areas.

The following was recorded for each sample: length and location of transect, weather conditions, time of day, and number of tourists encountered. For each sighting the following was recorded: species; radial distance (r) from the observer to the animal, measured with a range-finder to the nearest meter; sighting angle (θ), measured with

Table 1. Species Surveyed

Mammals	Ground Birds
Agouti *(Dasyprocta punctata)*	Crested guan *(Penelope purpurascens)*
Central American spider monkey *(Ateles geoffroyi)*	Great curasow *(Crax rubra)*
Coati Mundi *(Nasua narica)*	Ocellated turkey *(Agriocharis occellata)*
Collared peccary *(Tayassu tajucu)*	Tinamous (*Timamus major, Crypturellus* species)
Deppes squirrel *(Sciurus deppei)*	Plain chacalaca *(Ortalis vetula)* *
Mexican black howler monkey *(Alouatta pigra)*	Spotted wood quail *(Odontophorus gutlatus)* *
Red brocket deer *(Mazama americana)* *	
Tayra *(Eira barbara)* *	
White-tailed deer *(Odocoileus virginanus)* *	
Yuccatan squirrel *(Sciurus yuccatanis)* *	

* species observed but sample too small for analysis

a compass to the nearest two degrees; and animal behavior. The perpendicular distance (x) from the animal to the transect was then calculated as $x = r(\sin\theta)$. The horizontal distance from the observer to the base of the tree was measured and recorded as r when animals were found in trees. When animals were observed in groups, the distance and angle to the nearest member of the group was measured and the number of individuals in the group was recorded.

For each study area, the density of each species was estimated using the computer program DISTANCE (Laake et al. 1994). Estimates are made based on the detection function or probability of observing an animal given the perpendicular distance observed from the line transect. This probability is related to the number of animals observed, the length of the transect, and the width of the observation band. The probability of detection is assumed to decrease with increasing perpendicular distance from the transect (Buckland et al. 1993).

The data for each replicate transect was pooled. Where necessary, the data was stratified by transect and by week of observation to reduce the amount of variation. Estimates for species that travel in groups were determined by calculating the density of clusters of animals and the expected cluster size and then combining these to estimate animal density. The total length of the replicate transects and the largest perpendicular distance from the transect were used to compute the area over which density estimates were calculated.

The 95 per cent confidence interval was calculated for each estimate of density. Density estimates and confidence intervals were then compared between the two areas to estimate the potential impacts of tourism. Density estimates were considered to be significantly different if the confidence intervals did not overlap. P-values were calculated for each comparison using a Wilcoxon rank-sum test.

Table 2. Density Estimates and Confidence Intervals

Species	Location	Density Animals/km^2	95% Confidence Intervals (Animals/km^2)		p[1]
Agouti	Ruins	160.24	81.69	314.33	0.0296
	Control	14.48	3.81	55.02	
Coati Mundi[2]	Ruins	99.35	38.58	171.85	0.0123
	Control	1.00	0.12	8.47	
Collared Peccary[2]	Ruins	4.62	0.34	63.01	0.7933
	Control	1.80	0.18	18.26	
Deppes Squirrel	Ruins	32.26	9.52	109.38	0.5415
	Control	2.18	1.10	4.33	
Howler Monkey[2]	Ruins	7.28	1.76	30.21	0.0296
	Control	1.86	0.65	5.32	
Spider Monkey[2]	Ruins	170.81	108.43	269.09	0.8781
	Control	115.03	53.85	245.71	
Crested Guan	Ruins	0[3]	--[4]	--[4]	0.001
	Control	49.41	14.30	170.71	
Great Curasow	Ruins	10.85	5.35	22.02	0.0484
	Control	72.01	25.86	200.57	
Ocellated Turkey	Ruins	47.01	15.44	143.13	0.0191
	Control	0[5]	--[4]	--[4]	
Tinamous	Ruins	0[3]	--[4]	--[4]	0.0493
	Control	4.92	2.61	9.27	

[1] p-values calculated using a Wilcoxson rank-sum test
[2] calculated using the number of clusters of animals encountered and the expected or average cluster size
[3] while animals were observed, the calculated density did not differ from zero
[4] not calculated
[5] not observed in the control

RESULTS AND DISCUSSION

Density and associated 95 per cent confidence intervals were estimated for each species in each site (Table 2). Three mammal species (the agouti, coati mundi, and Deppes squirrel) and one bird species (the ocellated turkey) were observed to have greater estimated densities in the ruins than in the control. The other three bird

genera (the crested guan, great curasow, and tinamou species) have greater estimated densities in the control than in the ruins. The remaining mammal species did not show any apparent difference in density between the two sites.

The ocellated turkey was observed only in the ruins and appeared to have become habituated to humans. In addition, while turkeys were observed in the forested areas of the ruins, they seemed to prefer the open areas of the central plaza; habitat type may account for the difference in their densities.

Coati mundis, like their cousin the raccoon, are fond of trash cans and garbage dumps and have become habituated to the humans in Tikal, even begging food from tourists. This behavior could account for their increased numbers in the ruins.

Another explanation for the increased density of some animals in the ruins could be that these animals are under less predation pressure when out of the forest. Jaguar tracks and scats were observed along the transects in the control site, but not in the ruins. Decreased predation could be the cause of the increased densities of some of these animals.

The effects of tourists on animals densities appears to be species specific, with some species increasing in the tourist area, some decreasing, and others not being effected. Habituation of animals to humans and a probable decrease in predation pressure are likely causes of species increasing in areas with tourists.

The crested guan and the great curasow are hunted for food by humans. They may have developed a healthy fear of humans which could account for their decreased numbers in the ruins. Timamous are generally timid birds and prefer to inhabit areas with denser understories (Stiles and Skutch 1989), which may account for their prevalence in the control site.

While there was no difference in the density estimates for spider monkeys, there was an anecdotal difference in the behavior of these animals between the two sites. Spider monkeys in the ruins did not appear to respond to humans. In contrast, those in the control area shrieked, shook branches, and threw twigs at human interlopers.

EVALUATION OF METHODS

Distance sampling theory expands finite population sampling methods adjusting for the fact that some, possibly many, of the animals are undetected (Buckland et al. 1993). This method can be appropriate when the size of the sample area is unknown and objects are not detected for several reasons.

The number of animals observed is an estimate of the true density and the probability of detection. The probability of detection is a function of many factors including cue production, observer effectiveness, and the environment (Buckland et al. 1993). Distance sampling provides a broad method for estimating population density. While the total count of observed animals can vary for reasons

unrelated to density, using distances allows for meaningful estimates of density even with variability in detection caused by these factors (Buckland et al. 1993).

There are, however, a number of limitations with using visual line transect surveys and distance sampling methods. Three assumptions of distance sampling may have been violated in the project, introducing bias to the results. The first assumption is that transects are randomly placed and independently located. Constraints on establishing transects in the forest around the Mayan ruins made this impossible. The non-random placement of the transects is likely to have introduced bias because they followed tourist traffic. To reduce the bias due to non-independent transects, care was taken to not double count animals on adjacent transects.

The second assumption is that objects are detected at their initial location, prior to any movement in response to the observer. Animals move both in response to humans and of their own accord. This may increase or decrease the likelihood that they are observed. Density estimates depend on the direction the animals move, and whether they are seen prior to moving out of the observer's range of vision. This was also confounded by animals fleeing in response to tourists walking along the transects.

Visual line transect surveys and distance sampling methods were used to estimate animal population densities in areas of Tikal National Park with and without tourism to identify variations possibly explained by tourist pressure.

The third assumption is that objects directly on the line are always detected. This was likely to have held true during sampling except when the second assumption was violated and the linear distance between the observer and the animal was large.

Animals that travel in groups also pose a problem in the collection and analysis of data. The computer program DISTANCE and distance sampling methods can be used to calculate estimates using clusters of objects by calculating a density for clusters and expected cluster size. However, difficulty is encountered in determining what constitutes a cluster, what is the appropriate cluster width, and what distance to use for the distance from the cluster to the transect. For example, female coatis travel in loose bands but males are solitary; with spider monkeys, individuals travel in large troops, but break into smaller groups to forage (Emmons 1990).

Other sources of bias can result from observer presence, secretive animals, and habituation to humans. The presence of the observer has an effect on the animals which may be translated into the results. It may trigger the human-induced response that is being measured. Secretive animals may be missed using these methods. They may flee unnoticed or hide until the observer passes. In addition, the animals found in the ruins are habituated to humans. This decreases their propensity to flee and increases their probability of being observed, thus skewing the density estimates.

Prior to and at the start of the project, the Petén experienced an unusually lengthy and arid dry season. Water troughs located in the ruins may have been a source of water for many animals during this time, artificially increasing their densities in the ruins. Density estimates in both areas also may be inflated due to the tendency of some animals to travel along paths, such as those used as transects.

The study may have been further confounded by the fact that the control was not completely free from human traffic. Two men from the village of Uaxactun, located approximately 24 km north of the ruins, were observed one morning in the control area collecting xate palm. How frequently the Xataneros entered the area is unknown, nor is it known whether they were poaching. This presents a problem in that the control site may not accurately represent an "untreated" reference plot.

Finally, the small number of observations for most of the species analyzed in this study resulted in density estimates with large coefficients of variation. Pooling the replicates and stratifying the data reduced the variation slightly but larger sample sizes would have provided a better estimate.

Protected areas with increasing numbers of tourists interested in going "off the beaten path" should develop management strategies to minimize impacts of tourists on animal populations, such as concentrating tourists in already disturbed areas.

CONCLUSIONS

Biases in visual survey and distance sampling methods may confound results. The increased presence of some species in the ruins may be an artifact of their habituation to humans and may have increased the likelihood of their being observed. Because of the bias due to the effect of the observer's presence and limitations of using transect surveys, non-invasive methods such as infrared tripped cameras could provide a better estimate of animal densities and thus tourist impact. Remote camera trapping in Tikal has been demonstrated to detect more species, especially those likely to be sensitive to human traffic (Kawanishi 1995). These methods are usually more expensive than using visual line transect surveys. To avoid the problem of pseudo-replication, multiple control sites should be surveyed, especially in areas where humans may be encroaching on the "undisturbed" areas of a park.

However, trends do show that the effect of tourists on animal densities appears to be species specific. Some populations increase in areas with tourist activity, some decrease, and some show no apparent difference. Habituation of animals in the ruins due to human presence and a probable decrease in predation pressure on these animals are likely causes of their increased densities. This in turn may have secondary effects on the species composition of the ecosystem, including the flora, due to changes in distributions of herbivores and of seed dispersers.

National parks, which are attracting increasing numbers of tourists interested in going "off the beaten path" should develop management strategies to minimize the impacts of tourists on animal populations. This could include concentrating tourists in already disturbed areas, such as around the Mayan ruins of Tikal. However, as birders and other wildlife observers set off into the rainforest, they will be increasing the area of the park that they are affecting. This demonstrates the need for more comprehensive and long-term research on the issue, as well as the investigation of other sites experiencing tourist pressure. Research is also needed to determine what levels and rates of tourist traffic trigger negative impacts on wildlife. This will enable park managers to set levels that will minimize the impacts on the biodiversity the parks are established to protect.

Distance sampling provides a broad method for estimating population densities that allows for the fact that many animals are not seen for various reasons. However, both distance sampling and line transect surveys have limitations which may introduce bias to the results.

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