THE GEORGE WRIGHT FORUM

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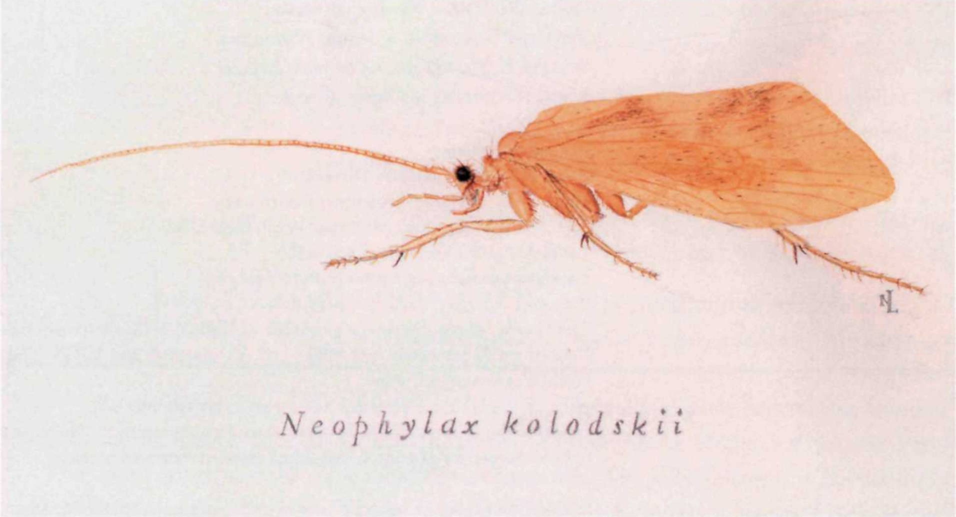

The All Taxa Biodiversity Inventory (ATBI) of Great Smoky Mountains National Park

GEORGE
WRIGHT
SOCIETY

Origins

Founded in 1980, the George Wright Society is organized for the purposes of promoting the application of knowledge, fostering communication, improving resource management, and providing information to improve public understanding and appreciation of the basic purposes of natural and cultural parks and equivalent reserves. The Society is dedicated to the protection, preservation, and management of cultural and natural parks and reserves through research and education.

Mission

The George Wright Society advances the scientific and heritage values of parks and protected areas. The Society promotes professional research and resource stewardship across natural and cultural disciplines, provides avenues of communication, and encourages public policies that embrace these values.

Our Goal

The Society strives to be the premier organization connecting people, places, knowledge, and ideas to foster excellence in natural and cultural resource management, research, protection, and interpretation in parks and equivalent reserves.

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The All Taxa Biodiversity Inventory (ATBI) of Great Smoky Mountains National Park
Becky Nichols, guest editor

On the cover: The cover artwork, executed in watercolor, depicts two species found or described during the All Taxa Biodiversity Inventory of Great Smoky Mountains National Park. The upper image is of the slime mold *Physarum viride.* The lower image is of the caddisfly *Neophylax kolodskii,* which was named to honor Joseph D. Kolodski, a National Park Service ranger who was killed in the line of duty at the park. *Neophylax kolodskii* is one of the species new to science described as part of the ATBI, and is known only from the park. The images are used with the kind permission of the artist, Nancy Lowe. She accepts commissions of all sizes for paintings and drawings of any living thing — plant, animal, fungus, or microbe. Her website is lookatyourfish.com, and she may be contacted at bugart@bellsouth.net.

SOCIETY NEWS, NOTES & MAIL

GWS to assist with training for Afghan cultural resources managers

In response to a joint invitation from the U.S. National Park Service's Archeology Program and the Cultural Heritage Center of the Department of State (DOS-CHC), the Society will be providing administrative and professional support for a program that will bring three senior cultural resource managers from Afghanistan to the United States for extended field training in archaeological site management. The initial trainees are expected to be three Afghan provincial directors of monuments. They will receive their training at NPS parks and archaeological sites in the Southwest whose characteristics are most similar to those found in Afghanistan. This program is intended as a first step in helping the cultural heritage personnel of the Afghan Ministry of Information, Culture, and Tourism improve their archaeological site management capabilities and develop productive working relationships with U.S. archaeologists, conservators, and cultural heritage specialists.

The program will consist of approximately two months of training followed by one week of in-country travel, including evaluation and follow-up planning meetings with the NPS Archeology Program and DOS-CHC staff in Washington, D.C. The program syllabus will cover all aspects of archaeological site management. It will be developed in further discussions among GWS staff, NPS unit managers and archaeologists, Afghan participants, NPS Archeology Program staff, and DOS-CHC staff.

Revision of U.S. World Heritage Tentative List moving forward

The GWS continues to assist the National Park Service's Office of International Affairs (OIA) in producing the first revision since 1982 of the U.S.'s Tentative List of properties deemed eligible for possible nomination to the World Heritage List. We are working with OIA and its principal consultant to help develop explanatory materials that describe the rather complicated legal and procedural process. The GWS website is being used as one of the main outlets to get this information to the public. Persons or groups interested in the possibility of having their property included on the Tentative List can now find the following information on our website:

- A *Questions and Answers* briefing on the Tentative List process;
- A comprehensive *Background Guide* to the U.S. World Heritage program;
- *Instructions* for preparing U.S. World Heritage nominations;
- A *Questionnaire* that must be submitted to the NPS Office of International Affairs as part of the nomination;
- A *Provisional Timeline* for the Tentative List revision process;
- *Sections of the Code of Federal Regulations* that govern the World Heritage Convention in the United States;
- *Congressional Research Service Reports* on the World Heritage program; and
- Additional background materials.

In July, a procedural notice was published in the *Federal Register* alerting people to the fact that information-gathering on the Tentative List had begun. In September, OIA held a briefing about the process for interested parties. This was done in conjunction with the two organizations responsible for reviewing sites being nominated to the World Heritage List: IUCN–The World Conservation Union (for natural sites) and ICOMOS, the International Council on Monuments and Sites (for cultural sites).

For more information on the Tentative List revision, visit the GWS home page (www.georgewright.org) and click the link under "GWS in Action."

Corrections

- The cover art for a recent issue of *The George Wright Forum* (Volume 23, Number 1) was a mural painting of Melrose Plantation, Louisiana, by Clementine Hunter, and was used by permission of Cane River National Heritage Area. We subsequently learned that the photograph of the painting was taken for the heritage area by James Rosenthal, photographer with the Historic American Buildings Survey, and should be credited to him.
- In Volume 23, Number 2, we mistakenly omitted the address of the third author of the article "Monitoring Trail Conditions: New Methodological Considerations" by Jeffrey L. Marion, Yu-Fai Leung, and Sanjay K. Nepal. Nepal's address is: Texas A&M University, Department of Recreation, Park & Tourism Science, 2261 TAMU, College Station, Texas 77845; sknepal@ag.tamu.edu.

ANNOUNCING

The George Melendez Wright Student Travel Scholarships

for attendance at
"Rethinking Protected Areas in a Changing World,"
the 2007 George Wright Society Biennial Conference on Parks, Protected Areas, and Cultural Sites

George Melendez Wright conversing (in Spanish) with Totoya, later known as Maria Lebrado, a granddaughter of Chief Tenaya and possibly the last person to have known Yosemite Valley before European contact. Yosemite National Park, 1928.

The George Wright Society has created the George Melendez Wright Student Travel Scholarships to encourage students from diverse ethnic, racial, and cultural backgrounds to participate in the Society's biennial conferences and to enhance their interest in the conservation and preservation of parks, protected areas, and cultural sites throughout the world. The goal of the scholarship is to encourage greater ethnic, racial, and cultural diversity among the park professions. The GWS seeks to encourage scholarship winners to pursue a profession in fields directly related to parks, protected areas, and cultural sites by giving them the opportunity to participate in a professional conference in all its dimensions, whether by taking part in sessions or networking with peers. All awardees will be assigned a professional mentor in order to maximize their experience at the conference.

At the 2005 GWS Biennial Conference, nearly 30 students benefited from the Travel Scholarships, and a like number is expected to be available for "Rethinking Protected Areas in a Changing World," the 2007 conference. Each scholarship includes a stipend of up to $500 for travel expenses, a conference registration fee waiver, and a year's membership in the George Wright Society.

WHO IS ELIGIBLE Full-time college/university students from ethnic, racial, and cultural groups that historically have been underrepresented in the fields of natural and cultural resources. Students must be at least juniors; graduate student status is preferred. Students from minority-serving institutions are strongly encouraged to apply. International students are eligible for consideration. The presentation of a paper at the conference is not required.

AWARD AMOUNT Registration fee waiver, year's membership in the George Wright Society, travel stipend of up to $500.

DEADLINE November 10, 2006.

HOW TO APPLY Fill out the on-line application at www.georgewright.org/2007.html.

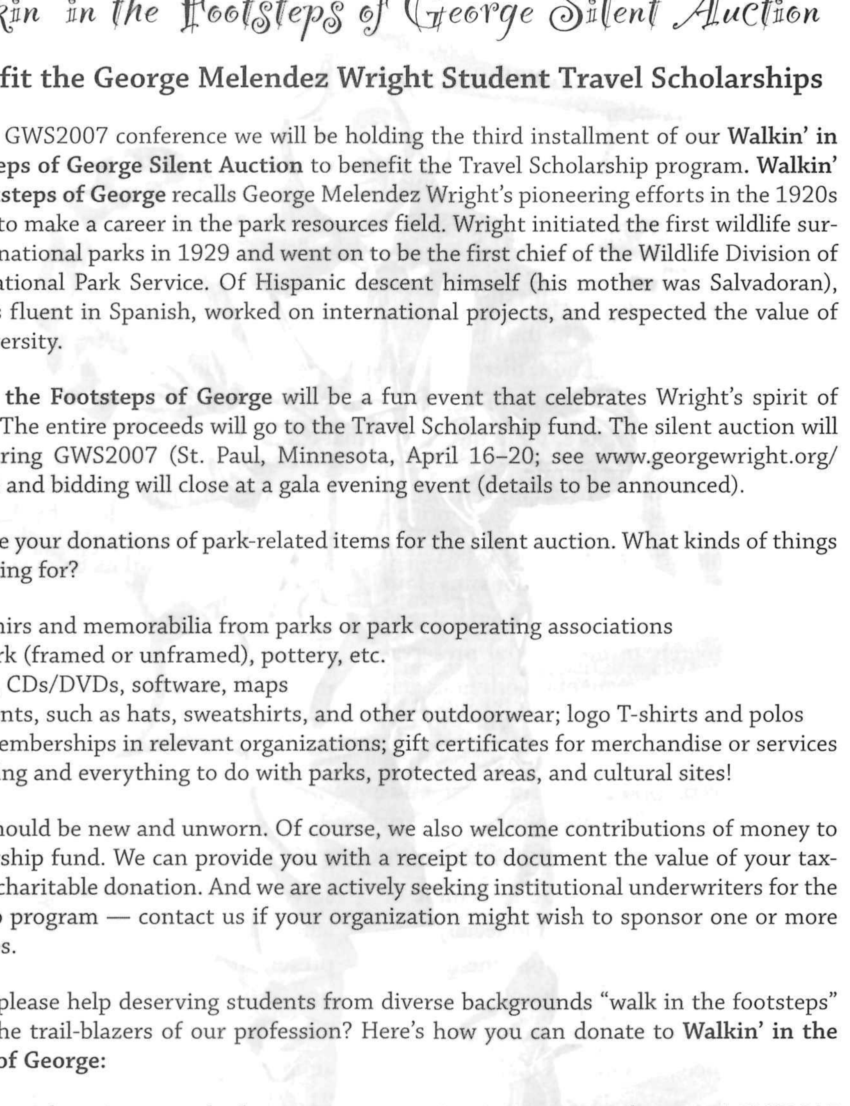
WHAT IS NEEDED TO APPLY Statement of purpose (see on-line form for details). Proof of full-time student status may be required.

NOTIFICATION Successful applicants will be notified by email in early 2007.

QUESTIONS? Contact Dr. Gillian Bowser, chair of the Scholarship Committee, at gbowser@tamu.edu, or Dave Harmon, GWS executive director, at dharmon@georgewright.org.

Walkin' in the Footsteps of George Silent Auction

to benefit the George Melendez Wright Student Travel Scholarships



During the GWS2007 conference we will be holding the third installment of our **Walkin' in the Footsteps of George Silent Auction** to benefit the Travel Scholarship program. **Walkin' in the Footsteps of George** recalls George Melendez Wright's pioneering efforts in the 1920s and 1930s to make a career in the park resources field. Wright initiated the first wildlife survey of U.S. national parks in 1929 and went on to be the first chief of the Wildlife Division of the U.S. National Park Service. Of Hispanic descent himself (his mother was Salvadoran), Wright was fluent in Spanish, worked on international projects, and respected the value of cultural diversity.

Walkin' in the Footsteps of George will be a fun event that celebrates Wright's spirit of adventure. The entire proceeds will go to the Travel Scholarship fund. The silent auction will be held during GWS2007 (St. Paul, Minnesota, April 16–20; see www.georgewright.org/2007.html) and bidding will close at a gala evening event (details to be announced).

We welcome your donations of park-related items for the silent auction. What kinds of things are we looking for?

- Souvenirs and memorabilia from parks or park cooperating associations
- Artwork (framed or unframed), pottery, etc.
- Books, CDs/DVDs, software, maps
- Garments, such as hats, sweatshirts, and other outdoorwear; logo T-shirts and polos
- Gift memberships in relevant organizations; gift certificates for merchandise or services
- Anything and everything to do with parks, protected areas, and cultural sites!

All items should be new and unworn. Of course, we also welcome contributions of money to the Scholarship fund. We can provide you with a receipt to document the value of your tax-deductible charitable donation. And we are actively seeking institutional underwriters for the Scholarship program — contact us if your organization might wish to sponsor one or more scholarships.

Won't you please help deserving students from diverse backgrounds "walk in the footsteps" of one of the trail-blazers of our profession? Here's how you can donate to **Walkin' in the Footsteps of George:**

- Mail your donations — whether money or auction items — in advance of GWS2007 directly to the GWS executive office. For auction items, be sure to include a note with (a) your name, full mailing address, phone, and email; (b) the name of the donor (if different from yours); (c) for artwork, the name of the artist (if known); and (d) your estimated value of the item(s). For direct donations to the Scholarship Fund, make checks payable to "George Wright Society." Please ensure that items arrive at our office no later than April 8, 2006. Address for mailed donations: P.O. Box 65, Hancock, MI 49930-0065 USA; for ground deliveries: 49445 US-41, Hancock, MI 49930 USA.
- Or you can bring your donations to St. Paul and check them in at the Conference Registration Desk.

Questions? Call us at 1-906-487-9405 or email conferences@georgewright.org.

The Antiquities Act and the Acreage Debate

Frank Norris

JUNE 8 OF THIS YEAR MARKED THE CENTENNIAL OF THE ANTIQUITIES ACT—a law that, by any standards, is a landmark in the history of U.S. land management policies. As many *George Wright Forum* readers know, there was a sweeping application of this act in the late 1970s that reserved a huge amount of acreage, and generated a huge amount of controversy. Questions arose, therefore, about the roots of that controversy, and whether the actions taken regarding Alaska were unique.

The Antiquities Act—which is formally designated "An Act for the Preservation of American Antiquities"—contains four key sections. Section 1 puts the federal government squarely in the cultural preservation business by threatening both fines and imprisonment for anyone who would "appropriate, excavate, injure, or destroy any historic or prehistoric ruin or monument, or any object of antiquity" on America's public lands. Section 3 provides for a process by which "recognized scientific or educational institutions" could legally conduct an "examination of ruins, the excavation of archaeological sites, and the gathering of objects of antiquity," and Section 4 is an enforcement provision. Finally, the Antiquities Act's second section provides for the U.S. president to declare as national monuments various "historic landmarks, historic and prehistoric structures, and other objects of historic or scientific interest" situated on the nation's public lands (34 Stat. 225; U.S. Code, Title 16, Sections 431–433). This paper will examine this second section of the Act a bit more closely, focusing particular attention on the acreage issue: namely, what does the Act say about how big a national monument should be, and how has the Act's acreage-related language fared over the years?

As Ronald Lee, Hal Rothman, Raymond Thompson, and others have ably explained in their histories of the Antiquities Act, it was the result of a convergence of two loosely related movements that arose during the 1880s: the protection of notable archaeological sites and the desire to preserve a variety of other significant public land parcels. Regarding archaeological site preservation, both federal bureaucrats and the academic community had become increasingly concerned about the loss of antiquities from the public lands (Lee 1970, 21–38; Rothman 1989, 34–51; Thompson 2006, 35–47). Congress, in fact, moved in March 1889 to preserve the Casa Grande, Arizona, archaeological site, and, beginning in 1897, the General Land Office (GLO) began preserving various prehistoric sites via a series of temporary land withdrawals (Lee 1970, 13–20, 39–46).

During this same period, Congress also recognized that other special lands needed protection. In 1872 it had established the first national park, Yellowstone, and on March 3, 1891, an amendment to the General Land Revision Act granted the president the authority to create permanent forest reserves by executive proclamation. Less than a month later, President Benjamin Harrison established the first timberland reserve, and during the next decade 41 forest reserves were set aside containing over 46 million acres of public lands (Chepesiuk 2005, 16; Lee 1970, 44).

In late 1899, the problem of how to protect aboriginal antiquities located on the public lands moved toward the legislative arena. Archaeologists, under the leadership of Dr. Thomas Wilson of the U.S. National Museum, contacted an Interior Department attorney to draft a comprehensive bill. At this time, the Interior Department—and more specifically the General Land Office—had some ideas of its own. The GLO, at the time, was in charge of the forest reserves. The agency was also aware of the need to protect prehistoric objects on the public lands (Lee 1970, 41, 47–48). But during the same period, as Ronald Lee has noted, "interesting discoveries were constantly being made of caves, craters, minerals springs, unusual geological formations, and other scientific features that appeared to merit special attention by the nation." But if these features were located in non-forested areas, the only real option was to ask for Congress to create a national park, which was a potentially long, unwieldy process. So as a result, GLO Commissioner Binger Hermann and his successor, W. A. Richards (Figures 1 and 2), asked Congress to enact general legislation that would authorize the president to establish national parks on the public lands, similar to the authority he already had as it pertained to forest reserves (Thompson 2000, 221).

Figures 1 and 2. Binger Hermann (left) and William A. Richards (right) served as General Land Office commissioners from 1897 to 1903 and from 1903 to 1907, respectively. The two men played an instrumental role in broadening proposed Antiquities Act legislation to include both non-archaeological areas and areas larger than 640 acres in extent. Photos courtesy of Oregon Historical Society, Negative no. CN020673 (Hermann); Wyoming State Archives, Negative no. 5568 (Richards).

The first congressional bill intended to protect archaeological sites on America's public lands was introduced in February 1900. But for a variety of reasons, the first several attempts to pass such a bill did not succeed (*Congressional Record* 33 [1899–1900], 1529, 1596, 2637, 3823, 4524; Lee 1970, 47–50). One of the major reasons for these early failures was that various westerners on the House Public Lands Committee objected to any new presidential reservation that might exceed 320 acres in size. These and other disagreements held up progress on an antiquities bill for more than five years (Rothman 1989, 21, 47; Lee 1970, 51–67).

In early 1905, a new impediment arose to passage of antiquities legislation when Gifford Pinchot convinced Congress to move the forest reserves—all 150 million acres of them—from the Interior to the Agriculture Department. This, of course, meant that any antiquities legislation had to cover more than just Interior Department lands (Lee 1970, 67). But then there appeared a young archaeologist, Edgar Lee Hewett, who was somehow able to overcome the problems and jealousies that had built up since 1900. In December 1905 he presented a draft of a newly conceived bill at a widely attended archaeological conference (Thompson 2000, 273–318; Lee 1970, 68–71). That draft, in turn, was passed on to influential congressman John F. Lacey (R–Iowa), who introduced it on the House floor the following January. The bill turned out to be so finely crafted that it proved acceptable to a broad spectrum of archaeologists, agency bureaucrats, and legislators, and, given Lacey's support, it passed Congress with almost the identical verbiage that Hewett had first put into the bill (Conard 2006, 49–61; Lee 1970, 71–72, 76–77).

Hewett, who was politically astute, recognized that the notion of protecting archaeological sites via a presidential designation was not particularly controversial, but he also recognized that westerners took a fairly dim view of similar protections for natural or scenic areas. And the notion of size was also a major stumbling block; westerners wanted any reservations to be kept small, while GLO officials balked at any size limitation. Hewett was able to satisfy both groups by suggesting that the proposed presidential withdrawals should include not only "historic landmarks" and "historic and prehistoric structures" but also "other objects of historic or scientific interest." And regarding the size issue, Hewett avoided a specific size limitation. He did, however, include language stating that any new monument "shall be confined to the smallest area compatible with the proper care and management of the objects to be protected" (Lee 1970, 49, 74–75; Ise 1979 [1961], 152–153) And on the House floor, Congressman Lacey assured a skeptical western congressman, John Stephens, that the object of the bill was "to preserve these old objects of special interest and the Indian remains in the pueblos in the southwest.... It is meant to cover the cave dwellers and the cliff dwellers" (*Congressional Record* 40 [1906], 7888).

Less than four months after he signed the Antiquities Act in June 1906, President Roosevelt established the first national monument at Devils Tower, in northeastern Wyoming. At first, Roosevelt was fairly restrained in his use of the Antiquities Act to establish new national monuments; his first nine national monuments protected relatively small sites, the largest being Petrified Forest, which covered approximately 60,000 acres (Lee 1970, 87–88; Harmon et al. 2006, 288). But during this period Congress began to chip away at Roosevelt's authority; it reacted to his liberal use of the Forest Reserve Act by revoking his ability to create new or expanded forest reserves in six heavily forested western states (*U.S. Statutes at Large* 34 [1907], 1256, 1271).

Against this administrative backdrop, the majestic Grand Canyon welled up as an issue. Back in February 1893, President Harrison had designated much of this area as Grand Canyon Forest Reserve (*United States Reports* 252 [1920], 455; Anderson 2000, 7). The Santa Fe Railroad completed its line to the South Rim in 1901. When President Roosevelt visited in 1903, the area was still largely undeveloped (Figure 3). He was so awestruck that he asked that there be no "building of any kind … to mar the … great loneliness and beauty of the Canyon.… The ages have been at work on it and man can only mar it." The railroad company, however, was already in the planning stages to build the El Tovar Hotel, and it opened a year later. Roosevelt, hoping to halt further development, turned the Grand Canyon into a game reserve in 1906. Just a year later, a local promoter and politician named Ralph Cameron announced plans to establish an electric-powered trolley line along the South Rim (Figure 4). In response, several groups protested to Chief Forester Gifford Pinchot, who relayed his

Figure 3. Theodore Roosevelt (second from left) and party at the Grand Canyon, 1903. U.S. President from 1901 to 1909, Roosevelt was an avid supporter of public lands protection. In June 1906 he signed the Antiquities Act. In 1908, having no realistic alternative, he proclaimed an 808,120-acre Grand Canyon National Monument—twelve times larger than any previous monument declaration. Photo courtesy of National Park Service Historic Photo Collection, Harpers Ferry Center.

concerns to Roosevelt (Collins 2005, 24–27; Lee 1970, 91; Anderson 2000, 5–6; Squillace 2003, 490–492). The president responded to the threat by converting more than 800,000 acres of the game reserve into a national monument (*U.S. Statutes at Large* 35 [1908], 2175–2176). Roosevelt's action, taken in January 1908, was a logical response to a serious and immediate commercial threat; even so, his decision to create a huge national monument based on scientific values was a major, precedent-setting move that, to some extent, made a mockery of the Antiquities Act's "smallest area compatible" clause (Rothman 1989, 65–67; Rothman 1999, 17; Harmon et al. 2006, 272).

In so doing, Roosevelt revived western fears of federal intervention. Congress, however, made no move to rescind the president's action, primarily because the influential Santa Fe Railroad controlled visitation to the Grand Canyon (Rothman 1989, 68; Runte 1994). But just a year later, Roosevelt established another large national monument that further antagonized western congressmen. Just two days before he left office, President Roosevelt proclaimed 615,000 acres on Washington's Olympic Peninsula as Mount Olympus National Monument, again citing scientific justifications for his action (Rothman 1989, 68–69; Rothman 1999, 17). But at Mount Olympus, which was less popular with tourists than the Grand Canyon, mining and timber interests loudly protested Roosevelt's land "lock-up," and in 1915 they moved—unsuccessfully, as it turned out—to have President Wilson cut the monument's acreage in half (Rothman 1989, 69, 99; Rothman 2006, 81).

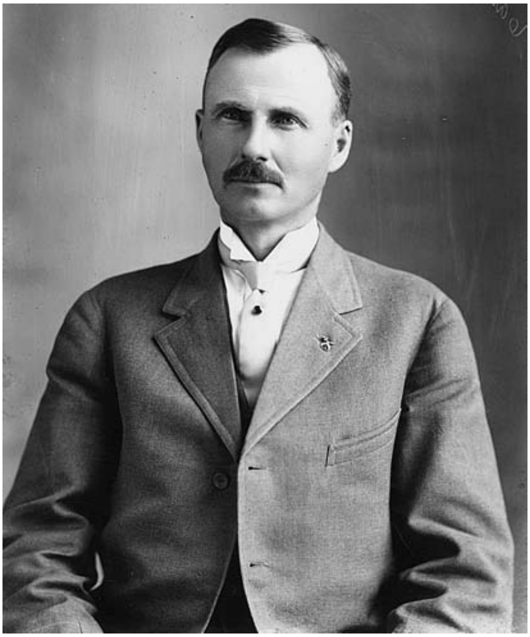


Figure 4. Ralph Cameron, a longtime political presence in northern Arizona, set in motion a series of events that resulted in Roosevelt's January 1908 proclamation of Grand Canyon National Monument. He later instituted a lawsuit to protect his South Rim mining claims; the 1920 decision in that case affirmed the legality of the 1906 Antiquities Act. Photo courtesy of Arizona Historical Society, photo no. B3965.

During the next decade two more large monuments were established: Katmai in 1918 and Glacier Bay in 1925. Both were in Alaska, both were established on scientific grounds, and both were patently unpopular to a broad range of local residents (Williss 2005, 1–2). Katmai, the scene of an enormous volcanic eruption in June 1912, had been visited by a series of National Geographic Society expeditions beginning in 1915. When President Wilson proclaimed the million-acre monument, virtually everything within its boundaries was covered by several feet of volcanic ash; even so, Governor Thomas Riggs stated flatly that "Katmai National Monument serves no use and should be abolished" (Norris 1996, 16, 38). A similar scenario unfolded at Glacier Bay, where ecologist William S. Cooper, in 1916, began studying glaciers and vegetation succession. In 1922, Cooper called for the protection of the upper bay in a speech to the Ecological Society of America, and in February 1925 President Coolidge proclaimed a 1.3-million-acre Glacier Bay National Monument. Local interests loudly opposed the action, but the federal government ignored the protests because Alaska was, at that time, a poorly represented territory (Catton 1995, 47–58, 74–82; Norris 1996, 45–49).

During the time that the original Alaska monuments were being considered, the viability of the Antiquities Act's Section 2 faced its first major court test. Ralph Cameron, who had provoked Roosevelt into proclaiming Grand Canyon National Monument back in 1908, defied government authorities by holding a mining claim at the head of the Bright Angel Trail—even though there were no commercial-grade minerals on the claim—and by demanding a toll from all who hiked down his trail. When the government moved to vacate his claim, Cameron filed a lawsuit, arguing that the national monument "should be disregarded on the ground that there was no authority for its creation." The suit went all the way to the Supreme Court. In April 1920, the court concluded that the Grand Canyon was indeed "an object of unusual scientific interest," so its protection as a monument was therefore a legitimate application of the Antiquities Act (*United States Reports* 252 [1919–1920], 454–456; Albright and Schenck 1999, 62, 64, 265–268; Anderson 2000, 8–10; Rothman 1989, 216, 231; Squillace 2006, 111, 128).

In the wake of the Grand Canyon decision, presidents established scores of new national monuments via the Antiquities Act. Some of these later became national parks, and other monuments were established on biological grounds in order to protect significant plant species. Throughout the 1920s and 1930s, no one questioned the Antiquities Act's fundamental legal basis; there was, however, an occasional public outcry against the act, along with "special interest lobbying and congressional carping, mostly by western representatives" (Rothman 1989, 94–101, 216, 220).

What did arouse controversy, however, was the reaction to President Franklin D. Roosevelt's use of the Antiquities Act to establish Jackson Hole National Monument in March 1943. The Wyoming congressional delegation had long made it known that they did not want Jackson Hole turned into parkland. State and local residents, therefore, were furious at Roosevelt's action, and in May 1943 the state of Wyoming filed suit challenging its legality. A key aspect of the state's argument was that the use of the Antiquities Act was invalid because the Jackson Hole area did "not actually contain any historic landmark, or any historic or prehistoric structure, or any other object of historic or scientific interest." In response, National Park Service (NPS) attorneys marshaled a number of historians, biologists, and geologists who testified that the area did indeed possess values worthy of the language prescribed by the Antiquities Act. A Sheridan, Wyoming, judge heard the case, and in August 1944 he sided with NPS (Getches 1982, 305; Rothman 1989, 214–221).

For the next thirty years, occasional sniping was heard about the Antiquities Act. Representative Wayne Aspinall (D–Colorado), for example, once threatened as part of negotiations over the Wilderness Act to remove the president's authority to establish new national monuments. The same scenario loomed as a possibility during Secretary Stewart Udall's effort to establish new national monuments during the closing days of the Johnson administration; at Death Valley National Monument, where a court heard arguments questioning whether the Antiquities Act applied to more than just archaeological sites; and during debates leading to the 1976 passage of the Federal Land Policy and Management Act, a law that discarded several other land-withdrawal statutes (*Congressional Record* 100 [1954], 10778; *Congressional Record* 125 (1979), 11681; *Federal Supplement, 2nd Series* 316 [2004], 1180; Squillace 2003, 499; Schulte 2002, 137; Rothman 1989, 227; Williss 2005, 18, 20). None of these threats diminished the Antiquities Act's broad applicability. But in late 1978, opposition rose once again to a high pitch. The place was Alaska, and the complaint was based on the matter of acreage.

The issue was the Alaska lands bill, which had been fiercely debated in Congress since 1977, shortly after Jimmy Carter had been elected president. A self-imposed timetable stated that Congress had to pass a comprehensive lands bill by mid-December 1978; if not, hundreds of millions of acres of withdrawn federal land, some of which had been earmarked as conservation areas, would be opened once again to homesteaders, prospectors, and other claimants. But Congress, despite a major struggle, adjourned in October 1978 without passing such a bill. Interior Secretary Cecil Andrus, reacting to that failure, met with Carter and considered a range of actions to protect these lands until Congress could act (Figure 5). One possible action included a massive implementation of the Antiquities Act. The state of Alaska, hoping to prevent Carter from implementing any of his proposed actions, filed suit against the president, arguing that his actions constituted an "abuse of discretion" and was therefore a violation of the National Environmental Policy Act. A federal judge, however, rejected the state's request for an injunction, and on December 1, President Carter issued proclamations for

Figure 5. Cecil Andrus served as the secretary of the interior under President Carter from 1977 to 1981. In late 1978, Andrus was instrumental in designating 56,000,000 acres as national monuments in Alaska, to protect them until Congress completed action on the Alaska National Interest Lands Conservation Act. Photo courtesy of National Park Service Historic Photo Collection, Harpers Ferry Center.

17 national monuments that covered more than 56 million acres of Alaska land. This area was far larger than the combined acreage for all previous Antiquities Act proclamations (*Federal Supplement* 462 [1978], 1155–1165; Williss 2005, 102–105).

Many Alaskans were in an uproar over Carter's action. Alaska Senator Mike Gravel stated that "the 56 million acres withdrawn is by no stretch of the imagination the 'smallest area' necessary for the 'objects' protected," and that "in only a very few distinct areas have historic or archeological values been of prime concern" (*Congressional Record* 125 [1979], 11678). Hoping to stall any future action on an Alaska lands bill, the state's two senators introduced a bill that would roll back Carter's various proclamations and also mandate that both houses in Congress concur with any proposed monument proclamation for areas larger than 5,000 acres. At a September 1979 hearing on the bill, Alaska's other senator, Ted Stevens, recognized that this bill had little chance of passage; he let it be known, however, that Carter had been "arbitrary and dictatorial" and that his "action was an outrage, not only to my state but to the entire west." Meanwhile, the state of Alaska continued to press its suit (U.S. Senate, 96th Congress, 1st Session, Report 96-69 [1979], 1–2, 11–12; *Congressional Record* 125 [1979], 11677–11682; *Anchorage Daily Times*, September 17, 1979, 3; *Anchorage Daily News*, March 8, 1980, A-3).

In June 1980 the state of Alaska, along with a lobbying group called Citizens for Management of Alaska Lands weighed in with a new lawsuit against the Carter administration. They asked the court to declare the withdrawals void and for the judge to define "exactly how far a president and Congress can stretch the 1906 act." The state was particularly concerned that the president's various proclamations had been used to protect "common wildlife and their habitat," and not the specialized "objects of historic or scientific interest" cited in the Antiquities Act (*Anchorage Daily Times*, June 6, 1980, B-1). But before arguments could be heard in the case, a similar case that the Anaconda Copper Company had brought against the president concluded that Carter was well within his powers to establish several of the Alaskan monuments. And soon afterward, Congress finally passed a comprehensive Alaska lands bill. President Carter signed the Alaska National Interest Lands Conservation Act in early December 1980, and the state of Alaska dropped its lawsuit (*Anchorage Daily Times*, June 29, 1980, A-10, and September 2, 1980, B-1; Williss 2005, 109-13).

For the next fifteen years, the Antiquities Act aroused little public debate. But President Clinton and his Interior Secretary, Bruce Babbitt (Figure 6), ignited a firestorm of controversy when, in 1996, almost 1.9 million acres in southern Utah were proclaimed as Grand Staircase–Escalante National Monument (Squillace 2006, 108). Clinton knew that the entire Utah congressional delegation opposed the move, and, in response, the Utah Association of Counties, joined by the Mountain States Legal Foundation, filed suit against Clinton and other administration officials. In addition, several House members introduced bills in 1997 to reduce the president's authority to establish new monuments. The most publicized bill that year, the National Monument Fairness Act (H.R. 1127) sponsored by Representative James

Figure 6. Bruce Babbitt served as President Clinton's interior secretary from 1993 to 2001. In 1996, and again in 2000–2001, he prevailed upon the president to declare millions of acres as national monuments, actions that aroused considerable resentment in various western states. Photo courtesy of the National Park Service.

Hansen (R–Utah), demanded that no new monuments of over 5,000 acres could be established without the concurrence of Congress and both the governor and the state legislature of the state in question. This passed the House, but it died in the Senate (*Congressional Record* 143 (1997), 21441–21443; Squillace 2006, 139).

Clinton thus weathered that legislative storm. Then, three years later, he and Babbitt prepared a number of new monument proclamations. Between January 2000 and the end of his term a year later, President Clinton proclaimed 19 more national monuments, ten of which protected more than 100,000 acres of federal land (Harmon et al. 2006, 295–297). Western congressmen again bellowed their dissatisfaction at Clinton's high-handed actions, and several tried to undo Clinton's proclamations and reduce the president's ability to create new monuments. In June 2001, 30 House members introduced a new National Monument Fairness Act. That bill, which was largely a repetition of what had passed the House four years earlier, passed the Resources Committee but was never considered by the full House (*House Journal* [2001], 690–691 and 2388).

Those hoping to diminish the scope of the Antiquities Act, therefore, pinned their hopes on a successful resolution of the Utah Association of Counties suit that had been filed back in 1996. That suit stated, among its other allegations, that the "Antiquities Act [was] unconstitutional because … only Congress ha[d] the authority to withdraw such lands from the federal trust." It also stated that President Clinton had violated the Antiquities Act in his 1996 proclamation because "he did not limit the size of the monument to the 'smallest area' necessary to preserve the objects." But in an April 2004 decision, the Utah District Court rejected the plaintiff's suit in its entirety. It noted that because Clinton had acted pursuant to the Antiquities Act, judicial review of his "exercise of discretion was not available" (*Federal Supplement, 2nd Series* 316 [2004], 1172–1177; Squillace 2006, 124–125, 136).

As a result of that decision and the many legislative and judicial actions that had preceded it, the Antiquities Act remains just as strong as when Congress passed it into law in 1906, and it still stands tall as one of the primary components of American conservation legislation (Rothman 1989, 230). The record of the past century has shown that the Antiquities Act has been used many times without controversy to protect specific archaeological and historical sites; however, the creation of national monuments containing substantial amounts of acreage has often generated considerable levels of opposition. In recent years, moreover, public opposition to large-scale withdrawals has often resulted in both legislative and judicial attempts to diminish the Act's scope. Despite these widespread disagreements over its applicability, the Antiquities Act is still a vibrant, viable piece of legislation that future U.S. presidents will doubtless use when the appropriate occasion presents itself.

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THE ALL TAXA BIODIVERSITY INVENTORY OF GREAT SMOKY MOUNTAINS NATIONAL PARK

BECKY NICHOLS, GUEST EDITOR

Prologue

THE ROLE OF NATIONAL PARKS IN OUR SOCIETY IS CLEARLY AND ELEGANTLY STATED in the National Park Service Organic Act of 1916. Managing the natural systems of national parks unimpaired, and accessible for present and future generations, has inherent intellectual challenges as well as implications for society that are larger and more fundamental than Congress could have realized. To fulfill this mission, a logical place to start is to know what we manage—the species that live in national parks. A fundamental reason for All Taxa Biodiversity Inventories, for me, is stated in the caption for a recent letter from Russell Train to the editor of the *New York Times:* "National Parks are for Americans of All Species." We should get to know them.

A second park management task would be to know how these resources interact with their world and with each other. Thomas Jefferson apparently understood this, opining "For if one link in nature's chain might be lost, another might be lost, until the whole of things might vanish by piecemeal." We must understand these links.

The National Park Service thus owes a great deal to the pioneers that conceived and launched our first All Taxa Biodiversity Inventory. In this case, the initiative of a few individuals working in a national park have demonstrated world leadership in answering the intellectual challenge of park management, and have made a tangible contribution to the preservation of biodiversity through the practical pursuit of knowledge, education, and public enjoyment.

This volume is one result of the All Taxa Biodiversity Inventory in Great Smoky Mountains National Park—a remarkable effort that will benefit the future of our parks and our own particular species most of all.

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The ATBI in the Smokies: An Overview

Peter White and Keith Langdon

Introduction

THERE IS A FUNDAMENTAL FLAW in how most parks and other natural reserves have been managed. In general, we have ignored a basic principle that would be fatal in the competitive world of business: we have never attempted a comprehensive inventory of our resources. This is surprising since the clearly stated purpose of most governmental and non-governmental conservation organizations has always been to protect and preserve the natural and cultural resources entrusted to their stewardship. How can we be intelligent stewards if we do not even know what kinds of resources we have, where they are found, their rarity, or, in the case of natural resources, some inkling of their ecological role?

In the summer of 1997 these questions were lamented by a handful of U.S. National Park Service (NPS), U.S. Geological Survey (USGS), and university professionals involved in natural resources stewardship and science at Great Smoky Mountains National Park. It was noted that over the years we were increasingly being forced to make many resource-impacting decisions without an adequate basis to judge the impacts on native species and natural processes. What we knew about threats to our resources, although not unique to the park, was alarming: exotic insects, fungi, plants, and fish were devastating certain natural communities; some forest types were being entirely lost; some of the highest depositions of nitrogen and sulfur in North America were occurring here; and 24-hour ozone levels were higher than in major cities in the region. Additionally, the park's general locale was rapidly developing, which meant loss of integral habitat exterior to the park. Within the park, an increasing number of road, land-trade, utility corridor, and other projects were being proposed by politicians, other agencies, and/or corporations. The consensus among Smokies' staff was that some of these proposals had the clear potential to cause drastic and permanent losses of species, but which ones? Where were they? How many occurrences did we have? What was their most sensitive season? What other species or natural processes were the rare ones dependent upon? We needed to know most of the answers to

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Ed. note: The George Wright Society and the guest editor are grateful to Charles Wilder and Jeanie Hilten of Discover Life in America for providing most of the photos of the ATBI that appear in the following articles, and to the individual photographers for their permission to reproduce them. We also thank Nancy Lowe for allowing us to reproduce her artwork on the cover—for more information, see the note at the bottom of the table of contents page.

these questions before the projects were planned, or even conceived. We needed a comprehensive, practical approach to discovering the biodiversity of the Smokies, and we needed to get the bulk of it accomplished in a relatively few years. We discovered we needed an All Taxa Biodiversity Inventory, or ATBI.

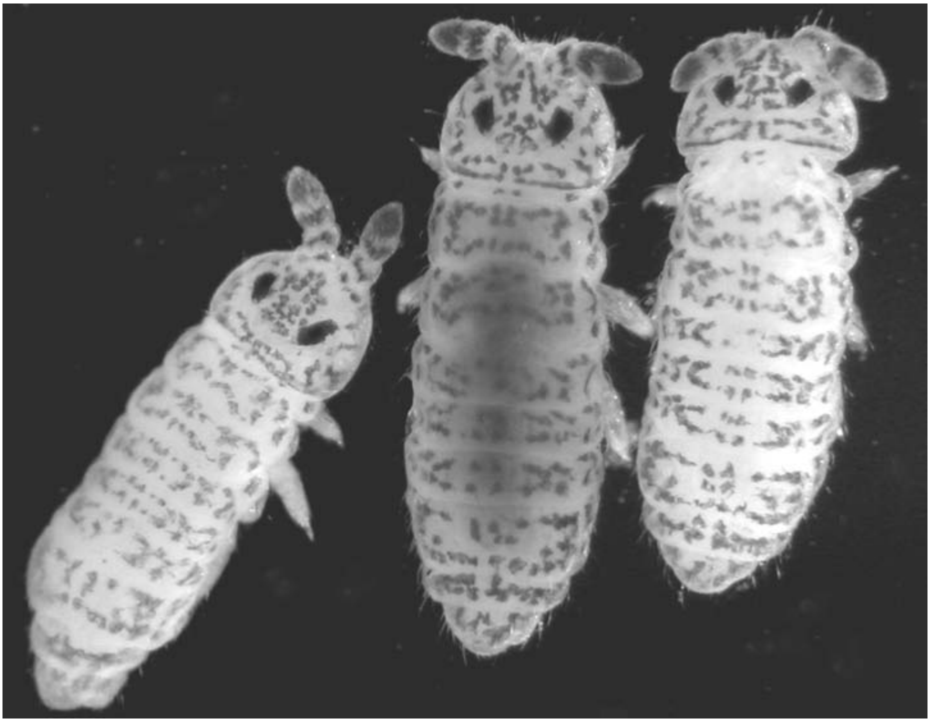
What is an ATBI?

Dan Janzen, the renowned ecologist, first conceived of the idea of an All Taxa Biodiversity Inventory, and coined the phrase, while conducting research in Costa Rica. Janzen's concern about rapid losses of tropical biodiversity prompted him to convene an international workshop to develop an approach for completing comprehensive inventories in a short amount of time (Janzen and Hallwachs 1994). However, an initial attempt at an ATBI in the Area de Conservación Guanacaste in northwestern Costa Rica was terminated in 1996 when the quasi-governmental organization responsible for receiving international funding and donations re-directed millions of dollars to other scientific endeavors.

Some of the words in the phrase "All Taxa Biodiversity Inventory" may be unfamiliar to the non-scientist. "Taxa" is the plural of taxon (taxonomic group); therefore, "all taxa" refers to all living things. "Biodiversity," though becoming a term more commonly used, is a relatively recent entry to the English language. The phrase "biological diversity" was first used in 1980 and the contraction in 1985. The simplest form of biodiversity is called species richness—the number of species found in a particular area—but that is just one component. While most people have an image of biodiversity as representing the biological variety across the living world, formal definitions include genetic diversity (on which each species depends) and ecosystem or habitat diversity (which provides the environmental setting and supports the lifestyle and interactions of those species).

An ATBI brings into focus the diverse worlds of all organisms, including species in more obscure groups. For example, of the more than 600 species new to science discovered since the ATBI began in the Smokies, many belong to the following categories: algae, lichens, mollusks, worms, spiders, crustaceans, pauropods, springtails, flies, moths, and beetles. The word "all" therefore represents the essence of this new thrust in research. Taxonomists often become specialists on a particular group of organisms, and so they rarely have the opportunity to work with taxonomists who are outside of their own area of interest. ATBIs, including the Smokies project, have created a context and forum for these specialists to reconnect to a more inclusive view of the tree of life and the diversity of organisms that have evolved and proliferated across the earth.

It is important to understand that the goals of an ATBI include compiling species lists, but lists by themselves are of little direct conservation value. An ATBI collects information on habitat, distribution, time and date of occurrence for the species observed, abundance, and where possible, life history information. All groups are included and eventually targeted for research, but no one is under the illusion that every single species will be found. This is impractical even for a smaller reserve, and not a primary goal of an ATBI (see Parker and Bernard, this volume). An ATBI should seek also to document and understand the ecological interactions and roles of the species that are found, such as para-



Cosberella lamaralexanderi, one of the springtail species new to science found by the ATBI. Photo courtesy of Ernest Bernard / DLIA.

sites, hosts, pollinators, or seed dispersers. The project must also incorporate approaches that lead to better understanding of conservation threats. In essence, an ATBI is about the discovery and taxonomic identification of species and the creation of museum specimens and data that document those species, but it seeks to develop taxonomic information in an ecological, conservation, and educational context.

The inventory in the Smokies

Great Smoky Mountains National Park is known for its biological diversity, especially in some familiar, charismatic groups, such as salamanders and vascular plants. But with its physical and geographic characteristics, it seemed probable that most of the park's natural wealth of species had yet to be discovered. There have been many past scientific efforts in the park which have provided excellent information on resources, but many of these were often sporadic and serendipitous, providing only minor relevant data for stewardship purposes, since that was ancillary to the research hypothesis being tested. At the rate we were accumulating inventory data in the past, it was roughly estimated that it would take about 150 years to complete a basic inventory of species in all groups of life. Clearly we did not have nearly that much time.

In the fall of 1997 a call was issued to interested scientists and others to attend a hastily convened, multi-day conference on the possibility of conducting an ATBI at the Smokies. It was scheduled for December

1997. Over 120 people, mostly from the sciences and especially the taxonomic community, participated—almost entirely on their own funding. Costa Rica had already been organizing centralized efforts at conducting biodiversity surveys for selected biological groups, and several biologists who work in Costa Rica, including Dan Janzen and Winnie Hallwachs, attended the initial ATBI conference as advisors. Several key points emerged from this intensive workshop:

- All agreed that a second attempt at an ATBI was imperative and that the Smokies was a good venue for that attempt.
- This project was too large for any one park, university, or museum to plan and manage. A new, private, non-profit organization, Discover Life in America (DLIA), was created and eventually incorporated. Membership and the board were drawn from the scientists and educators involved in the ATBI.
- There were to be three major thrusts or beneficiaries of the project: stewardship, science, and education. These three foci were to be integrated into operations as much as practical and the science focus had to be the lead. Biopharmaceutical activities were not a goal.
- The most effective and efficient approaches needed to be designed and tested as a pilot for other ATBI projects that hopefully would follow.
- Scientists identified their needs as: housing, a place to work, minimal bureaucratic "entanglements," "seed grants" to act as catalysts for other funding, and greater access and involvement with park staff. The park agreed to push for better facilities for visiting scientists, and to complete planned mapping of geology, soils, and vegetative communities to facilitate sampling design.

Superintendent Karen Wade and especially Assistant Superintendent Phil Francis became deeply involved in the planning aspects of the ATBI. In a ceremony on Earth Day, 1998, NPS Deputy Director Deny Galvin officially sanctioned the Smokies ATBI effort. No funding was made available to the project by the agency, however, beyond the part-time efforts of several biologists. A series of DLIA organizational meetings, internal agency meetings, scores of presentations to various civic, environmental, educational, and governmental groups—including to the White House Office of Science and Technology Policy—ensued over the next two years. These discussions reinforced the consensus that the Smokies effort had to be designed as a pilot for other follow-on projects.

Fortunately, funding and organizational support was provided initially by the Friends of Great Smoky Mountains National Park, an organization that seeks donations on behalf of the park. Eventually the Great Smoky Mountains Association, which is an official cooperating association of the park, also became a reliable supporter of the project. Total annual donated amounts averaged about $150,000. This allowed DLIA to hire a full-time director and eventually two part-time employees to plan and conduct operations. Park staff filled in gaps where tasks could not be performed by the non-profit or the many volunteers that the DLIA staff trained.

Park staff, USGS staff, educators, and especially scientists started to submit proposals for funding from other sources, and have been increasingly successful for short-term projects on specific topics, but the core administration and coordination of the project are supported primarily by donated funds. The National Science Foundation has recognized the merit of the project and has funded ATBI scientists on several projects aimed at specific species groups (see Langdon, White, and Nichols, this volume); however, the largest source of support has always been the donated time of the approximately 200 cooperating scientists, many educators, and volunteers.

The Science Plan

The Science Plan for the ATBI in Great Smoky Mountains National Park (White et al. 2000; http://www.dlia.org/atbi/quarterly_newsletter/pdfs/science_plan.pdf) was written to outline the goals, approaches, and structures for this large project. Five themes were articulated: (1) coordination across all taxonomic groups; (2) the Taxonomic Working Group, or TWIG, structure; (3) taxonomic inventory in a conservation and ecological context; (4) Geographic Information Systems as an organizational and analysis tool; and (5) involvement of the public and students of all ages. The Science Plan also lists questions to be addressed in the ATBI because these form the basis of how we can create an overall understanding that is greater than the individual field projects that are carried out. We briefly review those questions here under two headings from the Science Plan: (1) what explains patterns of diversity and distribution; and (2) how should the ATBI be done. We start with the first (and simpler) question, and then turn to a more complete discussion of the second question.

What explains patterns of diversity and distribution? Major factors that determine species distributions are the physical environment (warmth, moisture, geology, and soils), disturbance history (human and natural), and spatial properties (how large or isolated a habitat is, and the spatial location of habitats relative to other terrain features). Species with different niche characteristics, vagilities (the tendencies and abilities of species to move to different areas), and rates of gene flow will react differently to the park's environments, histories, and spatial characteristics so that the answers to these questions will differ in interesting ways among taxonomic groups. Examples of questions that address these issues include: Does diversity increase with warmth, moisture, and productivity, and decrease with elevation? Is diversity higher in old-growth compared with second-growth areas? Are some species limited to old-growth or second-growth areas? Is diversity higher in areas of large contiguous habitat than in small isolated habitats? How do environment and geography contribute to species diversity patterns in groups with different inherent vagilities and rates of gene flow? How do we use known occurrences to predict complete distributions from computer map data? Is diversity correlated among groups and can we use diversity in one group (e.g., plants) to improve the predictions of diversity in another group (e.g., insects)?

Answers to questions like these help conservation managers because they expand the understanding of the factors that influence the occurrence of species and create observations that provide evidence about such threats as exotic species invasions, air pollution, and habitat loss and fragmentation. Information from large wilderness areas can also help us develop an understanding of past human effects. For example, exploitive logging in the southern Appalachians caused severe soil erosion in many watersheds. The old-growth forests in the Smokies reveal soil organisms that may play an important role in forest productivity—and which are now missing from the formerly logged lands, both inside and outside the park.

How should an ATBI be done? In the Science Plan we describe two approaches to building taxonomic knowledge: traditional collecting and observing, and structured collecting and observing. We briefly describe these approaches here (see Parker and Bernard, this volume, for a more in-depth discussion).

Traditional taxonomic exploration. "Traditional collecting and observing" is the title we use for the typical field work of taxonomists. Based on their knowledge and experience of where to find new species, taxonomists explore the landscape intuitively. Because their work is inherently experience-driven, it tends, depending on that level of experience for each scientist, to be an efficient way to build a species list and to add knowledge about the occurrences (locations, time) of individual species. However, it is difficult to evaluate the completeness of the lists generated—the relationship of the species list to the amount of effort and habitats covered is often left implicit rather than made explicit.

Structured sampling, ecological zip codes, and accessibility. By contrast, structured collecting and observing adds a systematic sampling approach in which biodiversity reference areas or plots are arrayed

Hanging a flight intercept trap during a 2006 beetle blitz at White Oak Sink. Photo courtesy of Laura Childers / DLIA.

against the environmental factors that correlate with species distributions. The work of USGS researcher Chuck Parker in developing and testing passive structured sampling protocols has sharpened our understanding of the value and difficulty of this approach (see Parker and Bernard, this volume). It is difficult to develop protocols that aim to maximize collection of taxa, while minimizing collection of specimens and impacts, for the least effort and expense.

We are also developing sampling designs based on environmental gradients. One of our research teams (Peter White, Todd Jobe, Dean Urban) is exploring the concept of "ecological zip codes" which uses computer map data to assign an "ecological address" to every 30x30-m location in the park. In the current iteration, the ecological zip codes represent the temperature, moisture supply, and insolation (the amount of solar radiation an area receives). Other factors (e.g., soil, vegetation, fire history, and old-growth vs. second-growth forest) can be incorporated through direct contrasts of areas that cover the same range of other physical environmental factors. The zip code map can be used to select plots and reference areas in order to ensure that the observations cover the environmental variation of the park, but it can also be used to model the environmental habitat of species from location data and to find the extreme habitats (e.g., the coldest and wettest places in the park) for carrying out targeted surveys.

Graduate student Todd Jobe has also modeled the accessibility of each 30x30-m location in the park by calculating the amount of human energy required to reach that location by foot. This information can be used in two contrasting ways: first, to estimate the bias associated with accessibility (e.g., the most accessible locations have received the most inventory effort) and, second, to design sampling strategies that are efficient with regard to resources because they return the greatest information per unit effort (whether measured in time, area covered, or funds spent).

In carrying out an ATBI in the Smokies or elsewhere, the same issue arises; namely, that the total number of species that occur is not known before the start. We are reminded of a remark made by Phil Francis, then the park's assistant superintendent, at one of the annual ATBI meetings. He said that the question of how many species are in the Smokies brought to mind a frequent question from visitors to Mammoth Cave National Park: "How many miles of unexplored caves are there?" This, in fact, is the ultimate question that an ATBI grapples with. The number of species is unknown, and the rarest species often make the prediction of total diversity uncertain. But it is also important to realize that completeness is not the only goal of an ATBI: our goals also should be to advance knowledge as far as we can and to understand where we are on the knowledge-versus-effort curve. In striving to achieve these goals, we not only increase the adequacy of our databases for conservation decisions, but we also build a firm foundation for those who come after us to continue scientific work in a wide variety of disciplines.

Summary

ATBIs build libraries of information that are useful even beyond the borders of the conservation areas where they are carried out. They support the development and survival of taxonomic knowledge for society as a whole, test new protocols, and help us enthuse and train new generations of field scientists—in this sense, ATBIs are carried out for science. But ATBIs also build the knowledge base needed to ensure that biological diversity is conserved in specific reserves. They provide a deeper level of understanding about species and the natural processes that perpetuate them than is possible to achieve by any other means. They allow us to be the most intelligent stewards possible of our parks and other reserves—so in this sense ATBIs are carried out to protect nature reserves. However, our society is steadily diverging away from actually experiencing nature, let alone developing an intimate knowledge and appreciation of it. This is especially true of our children (Louv 2005). ATBIs could stand on their own for science and reserve protection reasons, but with the many pressures facing today's societies, the long-term survival of natural systems inside and outside of reserves is probable only if the public and especially youth have those connections. So ATBIs are also carried out for educational purposes, to share that sense of discovery.

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The Science Approach to the Smokies ATBI

Charles Parker and Ernest Bernard

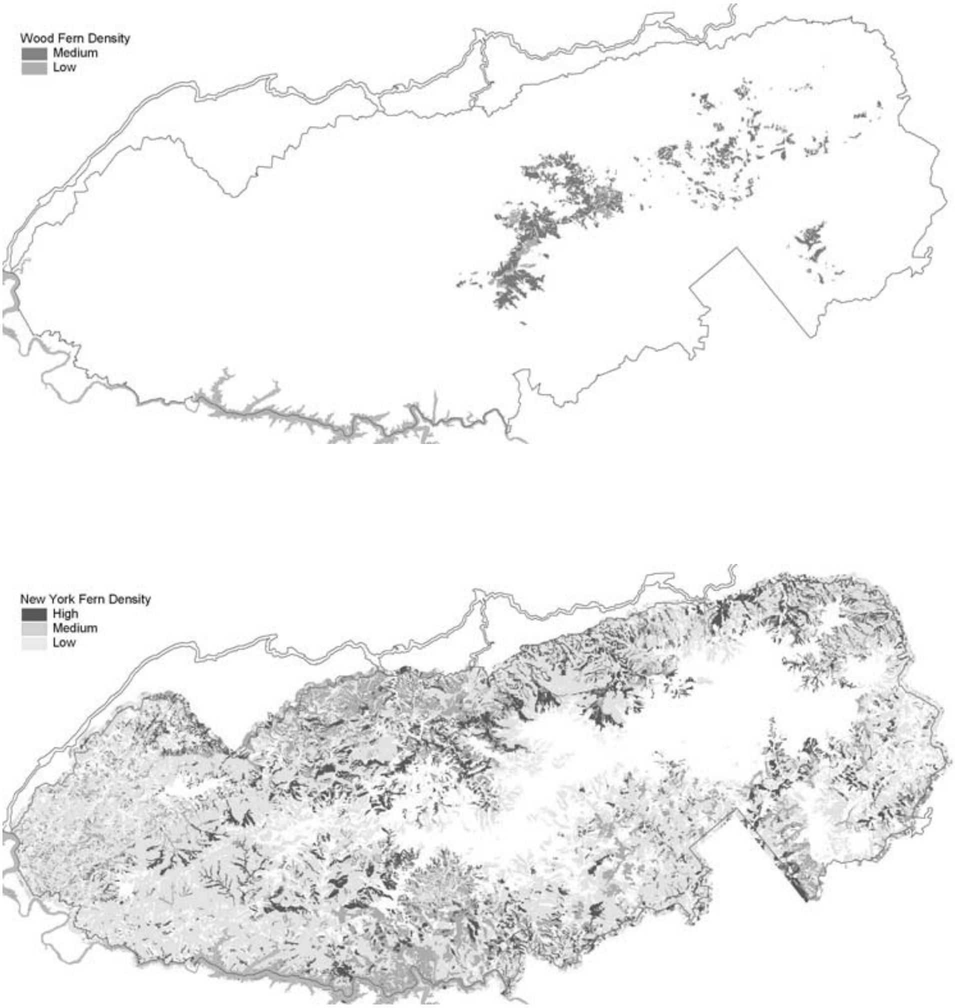
When the Smokies ATBI officially began on Earth Day, 1998, procedures for conducting a comprehensive inventory of life in a diverse natural landscape were not available. A "generic protocol" is contained in the report on a workshop held in 1993 to consider conducting an ATBI in Costa Rica (Janzen and Hallwachs 1994), and methods are available for selected groups of organisms (e.g., soil organisms—Hall 1996; fungi—Rossman et al. 1998; ants—Agosti et al. 2000). The science committee of the ATBI, therefore, developed a Science Plan to guide our initial efforts, relying on the needs for information as expressed by park resource specialists and on the knowledge and experiences of the scientists interested in participating. The Smokies ATBI Science Plan calls for a traditional sampling approach to operate in parallel with a structured sampling approach (see White and Langdon, this volume), and relies on taxonomic authorities organized into Taxonomic Working Groups (TWIGs) for the critical tasks of identifying specimens, describing species, developing species lists, and training students. Here we describe the traditional and structured sampling approaches, giving examples of the results from each approach, and how the TWIGs function to meet the goals of the ATBI.

The traditional sampling approach

The traditional approach is defined as the types of activities employed by taxonomic authorities to collect the species of their expertise, normally accomplished by these authorities visiting habitats favored by the organisms under investigation, and using collecting techniques most likely to result in specimens. These techniques may involve, for example, turning over rocks and inspecting them individually for minute pauropod specimens, sweeping with an insect net in vegetation for planthoppers, or spraying a mixture of cola and honey on bushes where certain kinds of parasitic flies aggregate. Other approaches include using a light to attract flying insects after dark, collecting leaf litter for processing in a Tüllgren funnel to sample arthropods, and examining individual flowers and mushrooms for thrips. Because of the specialized nature of many of these approaches, they are best accomplished by experienced authorities, usually working on their own or with a trained technician. A variation on the traditional approach is a foray, or blitz, in which groups of experts and dedicated volunteers conduct intense, short-term efforts focused on particular taxonomic groups or habitat types. Since the Smokies ATBI began, we have held 26 forays, 23 of them focused on taxonomic groups such as moths and butterflies, beetles, snails, flies, ants, slime molds, bats, and millipedes. The other three have focused on particular ecosystems: a leaf-litter quest, a high-country quest, and a karst quest. Finally, we have had highly successful fern forays for several years running, in which groups of scientists and volunteers hike designated trails in the park and map the occurrences of fern species following a specific protocol. To date, fern forays have covered more than 250 miles of trails, and the results have been used to develop GIS models of probability distribution maps of fern species throughout the park (Figure 1).

Traditional approaches are excellent for rapidly developing lists of species, and for finding unusual species that are restrict-

Figure 1. Probability distributions of two species of ferns in Great Smoky Mountains National Park. Probabilities were determined from the results of fern forays along 250 miles of park trails.



ed to unique habitats likely to be overlooked by collectors with less experience. Traditional methods of sampling can result in the collection of any type of organism, and in some cases do not actually require the collection of specimens. For example, observations by qualified ornithologists listening for bird songs can suffice as a reliable record of a species occurrence at a specified location at a particular point in time, without the need for a specimen to be collected. The U.S. Geological Survey conducted more than 4,000 such observation sessions of breeding birds in the park over a period of three years, resulting in nearly 75,000 observations of 115 species (Susan Shriner and Ted Simons, personal communication).

Of the more than 600 species new to science and the more than 4,400 new park records discovered since the beginning of the ATBI (see Langdon et al., this volume), more than two-thirds of each category resulted from traditional sampling. However, traditional approaches are less successful at providing the type of data needed to evaluate the completeness of an inventory for a group of taxa, and for quantifying relationships among taxa and community types. These types of data are more accessible using the structured approach.

The structured sampling approach

The structured approach is based on biodiversity reference areas and uses various types of standard traps that operate for long periods of time in every “ecological zip code” in the park (see White and Langdon, this volume). Structured sampling is a quantifiable approach that allows us to develop estimates of species–effort relationships for multiple taxa per habitat type simultaneously, and to discover biotic relationships at a scale that ultimately will permit modeling of the occurrences of numerous species across the park landscape. Of course, structured sampling is not appropriate for organisms that cannot be captured in a trap. Even for those organisms that can be trapped by some device, sampling is biased by the types of traps used. Malaise traps (Figure 2), a type of trap favored by entomologists, predominantly sample insects flying within 1–2 m of the ground, and more specifically, those insects that fly upwards when they encounter an obstacle. Malaise traps are less successful at sampling insects that drop to the ground

Figure 2. A Malaise trap in an acid bog on Andrews Bald, with an electric fence to keep bears and other wildlife away.

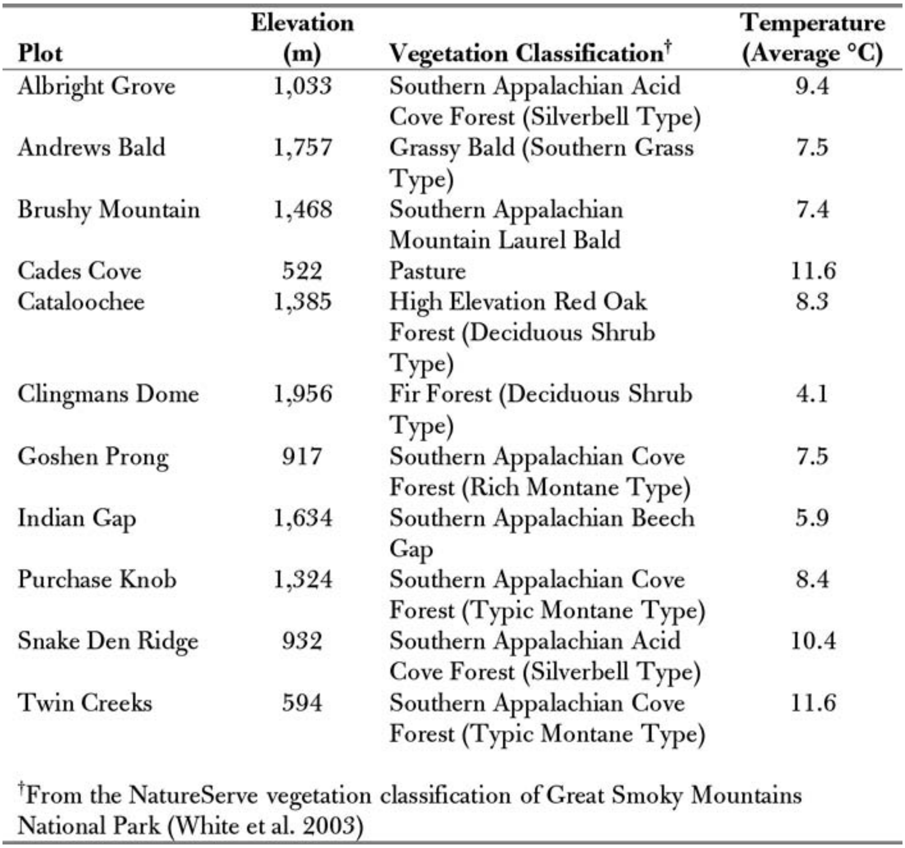
and fly away in the opposite direction when they encounter an obstacle. Some groups of flying insects are rarely captured in Malaise traps under any circumstances. Pitfall traps are designed to sample the leaf litter community of the forest floor, but collections are biased by the activity levels of the individuals in the community; for instance, springtails are more active than slugs. The type of preservative used in the collection cup, as well as seasonality, temperature, and moisture, are other qualifying considerations. Thus, several methods must be used simultaneously in order to sample different segments of the communities present. In order to overcome seasonality-, temperature-, and moisture-related variations, sampling should be extended over multiple seasons, preferably over several years. No consensus exists on how best to sample multiple communities that exist at one location. Therefore, a pilot study was designed to address this all-important question.

Pilot study design

The pilot study was designed to test techniques for adoption in the full-scale structured sampling program. Funding was obtained from the U.S. Geological Survey for a three-year study with the objectives of (1) determining how to efficiently sample and process many thousands of specimens using a variety of collecting methods in a variety of habitats, (2) estimating species accumulation curves and stopping rules for different taxa and methods of sampling, and (3) developing reliable approximations of the time, effort, and costs of doing the full-scale ATBI in Great Smoky Mountains National Park.

The first 19 ATBI plots were set up by the park's forest ecologist, Mike Jenkins, using the North Carolina Vegetation Survey methodology (Peet et al. 1998). We selected 11 of these plots for the pilot study, ensuring a range of habitat types from low to high elevation, including old-growth and second-growth forest, and grassy balds and heath balds (Table 1). The specifics of all 19 plots, including additional details about the 11 used in the pilot study, are found in Jenkins (in press). The initial invertebrate sampling design used in the plots included aspects of the efforts then being employed by a University of Georgia researcher to sample ichneumonoid wasps in Panama, Costa Rica, Georgia, and the Smokies. His design used paired Malaise traps in each plot. To this we added paired funnel traps (Lindgren traps, Figure 3) to sample the canopy fauna, and 10 pitfall traps to sample the litter fauna. Thus, we arrayed 14 traps on each of 11 plots (Figure 4). Sampling began in October 2000 and traps were left operating continuously until June 2003. Weather and other circumstances often prevented us from reaching every plot on an exact 2-week schedule, especially in the winter months, and occasionally, traps were damaged or destroyed by wildlife, tree-fall, or prescribed burning. Ultimately, we had 6,812 sampling events, totaling 129,380 trap-days.

Samples from each 2-week interval were sorted to TWIG level, generally consisting of an order of arthropods (i.e., flies, beetles, spiders). Selected taxa were segregated to finer levels, and ultimately sorted to the species level. These taxa were chosen because we or our cooperators have the taxonomic expertise to identify specimens of these groups to the species level. This is a relatively short list, which highlights a general problem facing not just the Smokies ATBI, but all similar comprehensive inventory efforts. That problem is the "taxonom-



Plot	Elevation (m)	Vegetation Classification†	Temperature (Average °C)
Albright Grove	1,033	Southern Appalachian Acid Cove Forest (Silverbell Type)	9.4
Andrews Bald	1,757	Grassy Bald (Southern Grass Type)	7.5
Brushy Mountain	1,468	Southern Appalachian Mountain Laurel Bald	7.4
Cades Cove	522	Pasture	11.6
Cataloochee	1,385	High Elevation Red Oak Forest (Deciduous Shrub Type)	8.3
Clingmans Dome	1,956	Fir Forest (Deciduous Shrub Type)	4.1
Goshen Prong	917	Southern Appalachian Cove Forest (Rich Montane Type)	7.5
Indian Gap	1,634	Southern Appalachian Beech Gap	5.9
Purchase Knob	1,324	Southern Appalachian Cove Forest (Typic Montane Type)	8.4
Snake Den Ridge	932	Southern Appalachian Acid Cove Forest (Silverbell Type)	10.4
Twin Creeks	594	Southern Appalachian Cove Forest (Typic Montane Type)	11.6

†From the NatureServe vegetation classification of Great Smoky Mountains National Park (White et al. 2003)

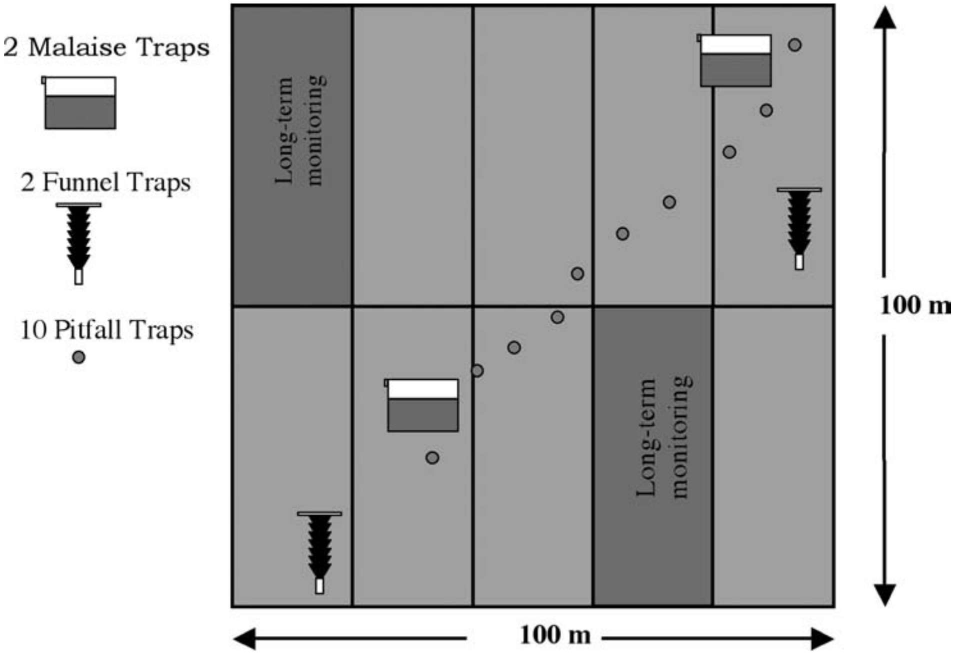
Table 1. ATBI plots used in the pilot study.

ic impediment," a critical shortage of taxonomic authorities available and willing to identify samples from such undertakings. This will be discussed further below.

Pilot study data: crane flies. Crane flies are collected in Malaise traps in large numbers, and an extensive list of species known from Great Smoky Mountains National Park was published decades ago (Alexander 1940, 1941). Thus, this group was selected for study by Matthew Petersen, then a graduate student at the University of Tennessee. The results were astounding; 176 species in 52 genera and 6 families were identified among over 9,000 specimens, bringing the total number of crane flies known from the park to 250 species (Petersen et al. 2005). Seventy species were recorded for the first time, including two species new to science (Petersen et al. 2004). The data also were analyzed for seasonal occurrence of species (Figure 5). The species shown in the plot at the top of Figure 5 occurs in the spring and early summer and at all elevations, but appears at low and mid elevations five weeks earlier than at the highest elevations. The species in the middle graph occurs in the fall and early winter at all elevations, but this species appears first at the higher elevations. The

Figure 3. A Lindgren funnel trap hung in the forest canopy adjacent to Andrews Bald.

Figure 4. The 1-ha monitoring plots used in the structured sampling pilot study, showing a typical layout of bulk sampling devices on the plot. The rectangles labeled "Long-term monitoring" represent areas intensively sampled for vegetation characteristics. See Jenkins (in press) for details on the vegetation measures recorded and the methods used.



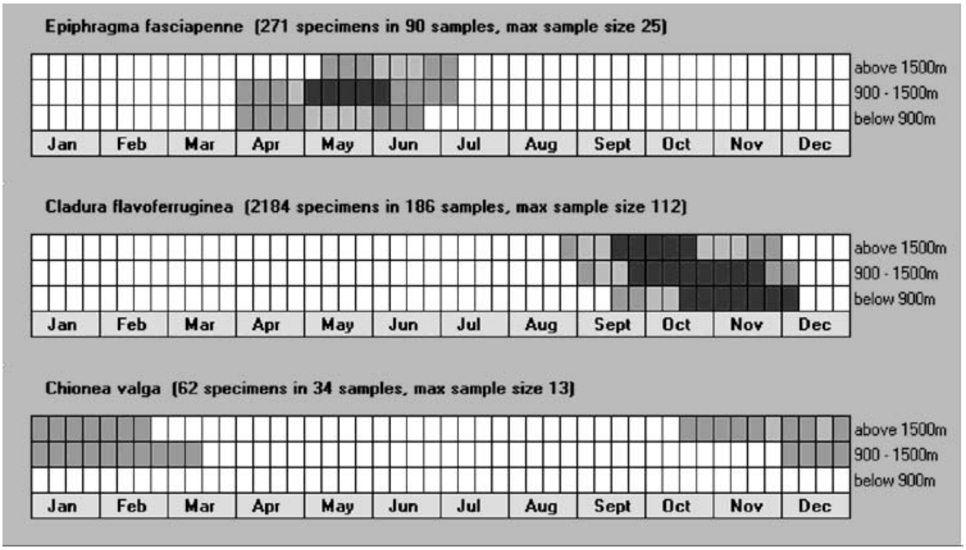


Figure 5. Seasonal occurrence of three crane fly species as revealed by the structured sampling pilot study of the Smokies ATBI. In each plot, the three rows of white boxes represent high, middle, and low elevations and approximate weekly intervals of time. The shades of gray in the boxes indicate relative numbers of specimens captured, with medium gray < light gray < dark gray.

species in the bottom plot is a winter-emerging species that does not occur at all in the lowest elevations of the park.

A major strength of data from a structured sampling program is its quantitative nature, which permits researchers to use statistical methods to investigate relationships among species and the environment. One of the most pressing questions in conducting an inventory is, "Can we stop yet?" To obtain the answer to this question we need to determine where we stand in terms of the number of species known to occur in an area versus the number of species believed to live in an area but not yet confirmed to occur there. The most reliable method for determining the answer is to develop species accumulation curves (Figure 6). These curves represent the rate at which new finds are added to the existing body of data based on some measure of the effort required to find them. At first, the curve of new discoveries is very steep as it is initially very easy to find new records with little effort (Figure 6). As efforts continue, the rate of discovery slows even if the level of effort stays the same. Eventually the curve will level to an asymptote that represents the maximum number of species that can be found. In practice, the asymptote is likely to never be reached, because resources (and patience) are limited. Therefore, statistical estimators of the limit can be used to determine what percentage of the theoretical maximum we have achieved, and how much more effort is required to achieve any desired level of completion. Using these estimators, Petersen (2002) estimated that actual richness in the 11 plots was 228 species, and that sampling had achieved 77% of the estimated total. To completely census the crane fly populations of the 11 plots used in the pilot study, without a change in the level of effort, would require an additional eight years of continuous sampling.

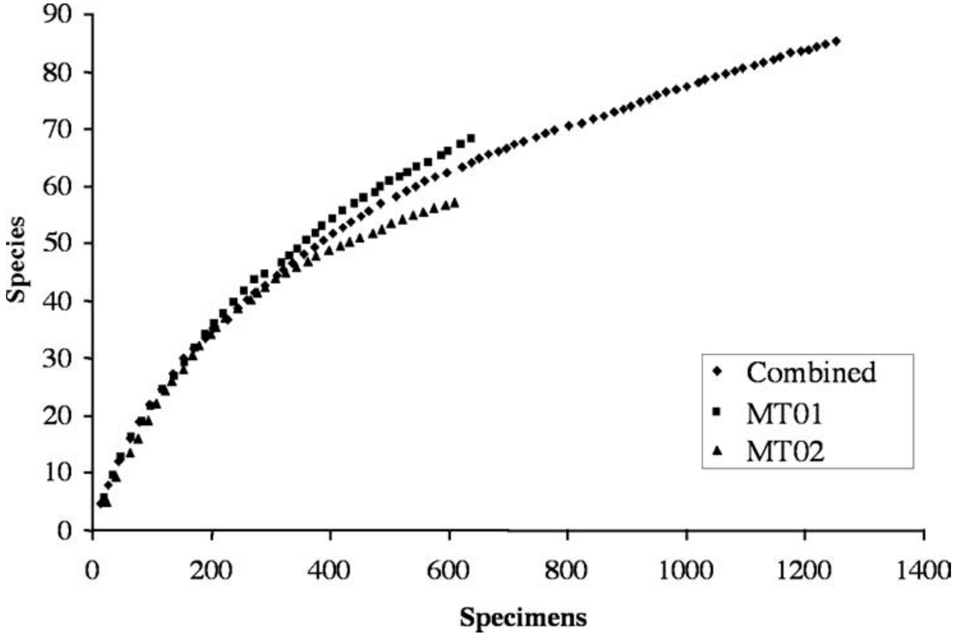


Figure 6. Species accumulation curve for crane flies from the two Malaise traps operated in the Twin Creeks structured sampling plot. The number of species found is plotted against the number of specimens examined, which is a measure of the amount of effort expended. The curves show no sign of leveling off, indicating that more sampling is required to reach an asymptote. MT01 and MT02 are the identifiers of the Malaise traps deployed on the Twin Creeks plot.

Pilot study data: Collembola. The only comprehensive list of Collembola (minute arthropods; springtails) from the Smokies prior to the ATBI contained 55 species (Wray et al. 1963). In the structured study, more than 150,000 Collembola were collected in pitfall traps and more than 20,000 in Malaise traps; together they comprise about 14,000 park records. Approximately 112,000 of these specimens (10,000 records) have been identified to the species level, and the discussion below refers to these identifications. All four orders of Collembola, 11 families, and about 120 species were collected in pitfall traps. Three orders, six families, and 21 species were collected in Malaise traps. The total number of species collected during the structured study is 127. Many of the Malaise trap taxa were never or rarely collected in pitfall traps, and would have been missed in a typical unstructured litter sampling effort. At least 25 of the taxa collected in the study are new to science, and descriptions are being published (e.g., Bernard 2006). The Collembola sampling effort with pitfall and Malaise traps appears to have been efficient at collecting most of the active or climbing species that can be obtained by these methods, since species-accumulation curves are near asymptote for most of the 11 sites. These kinds of traps are poor for collecting the many less-active species of springtails, which are better obtained with Tüllgren funnels.

Taxonomists and structured sampling

The linchpin of taxonomic inventories

is the taxonomic authority who identifies specimens, describes new species, and develops tools for non-experts to identify and understand the diversity of life. Unfortunately, there is a severe shortage of taxonomists, especially those who work on the most diverse groups of organisms, such as arthropods, fungi, and bacteria. This shortage has been termed the "taxonomic impediment" (Taylor 1983), and has serious consequences for biodiversity studies and conservation (Mikkelsen and Cracraft 2001; Hopkins and Freckleton 2002; O'Connell and Yallop 2002; Giangrande 2003; Terlizzi et al. 2003). The numbers of specialists who have the time and inclination to identify specimens for ambitious projects such as all taxa inventories seem to be in steady decline, with fewer young scientists going into taxonomy to replace those who retire or die. Those who do work in taxonomy often are so busy that they have little time to devote to identifications of large mixed samples of organisms to find the few gems of interesting specimens that may represent rare, unusual, or undescribed species. In the Smokies ATBI for example, we have been unable to find taxonomists with expertise in Hymenoptera willing to identify material from the park, with the notable exceptions of ants, mutillid wasps, sawflies, and bees. The majority of parasitic wasps, which number in the thousands of species, thus are being stored on shelves in the hope that some day authorities will be found to identify the samples. This limitation is true for other groups as well. Even when authorities are willing to identify Smokies material, they often have only limited time to devote to it, which results in a further difficulty. The bulk sampling methods used in structured sampling were operated continuously for several days or weeks, which resulted in enormous numbers of specimens of common species, as well as small numbers of rare or otherwise interesting species. In a sense, the original design of the pilot study was too successful for its own good. Since the end of the pilot study, the park has developed funding that has allowed us to procure the services of specialists in various groups to begin processing this backlog. Thus, some of the hyper-diverse groups, such as Diptera and Lepidoptera, are finally receiving attention where previously they had not.

A modified approach to structured sampling

Because of the problems mentioned above, and because of the difficulty of operating the plots on a continuous basis, we have modified our approach to the structured sampling program. The park has provided funds for a test of the revised protocols that is currently underway (Becky Nichols, personal communication). In the revised protocol, the structured sampling plots consist of points established in "ecological zip codes" by a GIS algorithm (see White and Langdon, this volume). At each point, a 6-m Malaise trap and a canopy trap are deployed. No pitfall traps are used. These Malaise traps are three times the size of the ones used in the original pilot study, and the canopy traps are larger than the Lindgren funnel traps. However, the traps are operated for just 48 hours every two weeks, rather than continuously. The shorter time frame allows us to collect the specimens dry, resulting in higher-quality specimens that we can pin, making the specimens more attractive to cooperating specialists. In addition, since the traps are operated for shorter time periods, they will not trap as many specimens, thus reducing the "fatigue of the commons" that the original samples produced. By using the larger traps for shorter periods of time, we hope that we will improve the quality of specimens, reduce the number of individuals of common species, and still maintain a high rate of new species recovery. In order to sample the litter fauna that the pitfall traps collected in the original pilot study, we will take litter samples periodically and process them in Tüllgren funnels. We anticipate that this approach will reduce the biases discussed above (more active species predominating) that pitfall traps are known to present.

Conclusions

The parallel operation of traditional and structured sampling approaches is highly productive. We believe it represents the most comprehensive and feasible way in which to inventory the biodiversity of complex terrestrial natural areas. The design of biodiversity reference areas and structured sampling plots can change from natural area to natural area, depending on the ecosystems represented. However, the inclusion of georeferenced plots at which specific protocols are followed strengthens the scientific credibility of the inventory program, and, for the Smokies, ensures that we will be able to achieve the management-driven goals of the effort.

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Science Education Programs with the ATBI

Jeanie Hilten, Jamie Cox, Dan Dourson, Heather Grossnickle, Jennifer Pierce, Susan Sachs, Paul Super, and Mark Wetzel

Introduction

THE ALL TAXA BIODIVERSITY INVENTORY (ATBI) in Great Smoky Mountains National Park has been, since its inception in 1998, a compelling and exciting project to benefit science, stewardship, and education. Discover Life in America (DLIA), the non-profit coordinator of the ATBI, has an active education committee composed of park staff and a variety of partners who support not only the work of scientists but also train and support the efforts of community volunteers, teachers, and students who are fascinated by this endeavor. As critical as reserve protection and scientific information are, without effective education and public involvement, few broad conservation goals will be achieved. In order for our national parks to gain from the growing knowledge generated by the project, an array of people from varied backgrounds must work together. For the ATBI to be successful, it is just as necessary to observe and cultivate these human interactions as it is to survey and document the other life forms of the Smokies.

A large array of educational opportunities is being explored with the ATBI, ranging from formal environmental education programs (e.g., NPS's "Parks as Classrooms"), to individuals in home-schooling programs who collect and sort samples. At one end of the spectrum are young children, who can learn and be inspired by the project, while at the other end are retired specialists, such as entomologists, who can help tremendously with the science. Additionally, adult volunteers have been tremendously helpful with ATBI activities, and the response from the local community has been overwhelming. Scientific results are made available to the public to promote enthusiasm for and understanding of biodiversity and to encourage and support conservation of biodiversity in parks and elsewhere. The fascination that people have with the discovery of diversity, and with the intricate, colorful world of hidden organisms, has also attracted the arts, with photographers, artists, and even musicians becoming involved.

ATBI education and outreach programs

The DLIA education committee has been involved with disseminating research results to the general public, among other activities. The goals of this committee are as follows:

- Educate people (students, teachers, park visitors, community, scientists, volunteers) about science, taxonomy, and biodiversity through the activities of the ATBI.

- Develop, implement, evaluate, and export innovative models for science education.
- Inspire, mentor, and develop future scientists and naturalists.
- Use the scientific findings of the ATBI for improved decision-making that fosters stewardship and resource conservation.
- Identify and garner human and financial resources; evaluate and document our effectiveness; disseminate information.

Much of this information is included in the park's public education programs, which aim to educate, promote awareness and stewardship, and inspire visitors to the park and interested groups outside of its boundary. These programs include classroom presentations, educational products, field trips into the park, and teacher workshops, among others. All of these efforts have shown positive results through student interest, involvement, and requests for return programs. The more formal programs include Parks as Classrooms (a program initiated prior to the ATBI, which now includes specific sections related to the project), and Junior Ranger programs (specific programs are oriented towards finding and identifying various invertebrate groups that are being studied through the ATBI).

Educational products related to the ATBI are being developed by the DLIA education committee to help bring examples of current issues and science topics into the classroom. Many teachers may be interested in the scientific findings, but are unsure of the best way to bring that information back to the classroom. The educational activities that are described on the DLIA website and at teacher workshops help to promote interest and provide teachers with what they need to conduct ATBI-related activities in their classrooms. Some schools have even developed their own "schoolyard ATBI." Biodiversity trunks filled with materials that can be used in the classroom have been developed, as well as videos, web pages, and exhibits.

The general community oftentimes does not know about the ATBI, nor do they know of the smaller creatures that they depend on every day. Until recently, much of the focus in educational programs has been on the megafauna, with less emphasis on the microfauna. Since the ATBI encompasses all life forms, related educational programs can now take advantage of the new things we are learning about many lesser-known groups. Programs about the ATBI inform the general community that every creature is important to the overall health of the ecosystem and highlights the need to protect not only the organisms but their habitat as well. When conducting youth education programs involving insects, there is usually at least one child who doesn't want to participate because they are repulsed, but by the end of the program, that same child is usually very interested in catching insects and in learning how they move, eat, and live their lives. This newfound appreciation is very rewarding to educators; now this child knows how important all of these creatures are, and perhaps will not think twice about helping protect places for these creatures to live.

One of the most important educational aspects of the ATBI is the connection between real science and the schools, teachers, and general public. Often, when given the opportunity to interact with real scien-

Snowy Cascade on Injun Creek, Great Smoky Mountains National Park. For some species, seasonality is an important consideration in evaluating their status. Photo courtesy of Charles Wilder / DLIA.

tists and actually conduct field work and collect data, students who initially do not seem very enthusiastic can become very participatory. One of the ATBI participating scientists, Mark Wetzel, observed that students who were initially quite reserved during an aquatic outing with a local high school quickly became enthusiastic and inquisitive about what they were finding under rocks in the stream and in the riparian vegetation, such as salamanders and aquatic insects. The teacher of that group later commented that his students talked regularly over the following couple of weeks about their experiences and discoveries, implying that at least some significant impressions were made on these students, which hopefully has increased their awareness of the fauna and flora in streams in their own area.

The ATBI has demonstrated that there is still much to be discovered by everyone, and people of any age and background can contribute to scientific knowledge. Teachers and students alike can benefit by learning about the actual scientific methods used in collection, and the chance to interact with the scientists and take that experience back to the classroom is very valuable. Additionally, young people may discover a career path or an area of life-long interest they might not have otherwise been aware of or considered.

Volunteerism

The recruitment, training, and support

of our volunteers have been particularly rewarding activities. Volunteers include everyone from high school students who become involved with particular projects, to retired folks who are experts in their field and are sharing their time and talents. Allowing volunteers a chance to see "behind the scenes" aspects of the science that takes place on a regular basis helps them gain a deeper appreciation for national parks and illustrates the important role that parks play in protection of resources and for activities other than leisure or recreation. When people realize the potential discovery of a new species, they get excited and want to help, and once the public appreciates the importance of these discoveries and the incredible biodiversity this park has, they often realize that they can contribute to the overall knowledge about its resources.

Volunteers can provide scientists with both tangible and intangible benefits. The tangible benefits include such practical contributions as collecting samples during the off-season; setting out traps in remote locations, which allows for a more thorough coverage of the park; and participating in long-term projects, such as fern forays. The more intangible benefits are ones that are carried back to the rest of the community from the ATBI experience, such as an understanding of the importance of the scientists' work and how it will help protect the resources of the Smokies and beyond. The communities around the park benefit whenever citizens get involved in the natural heritage that is in their own backyard. They gain knowledge, skills, and the reward of doing something useful and making a contribution to the park.

Dr. Ed Lickey (left) assists a volunteer with data collection while another volunteer checks his GPS unit during a fern foray at Cataloochee. Photo courtesy of Kemp Davis, Jr. / DLIA.

The 5,000th new discovery in the Smokies ATBI: the velvet leaf blueberry, *Vaccinium myrtilloides.* Photo courtesy of Heather MacCulloch / DLIA.

Student involvement

Young students can often rekindle in scientists that sense of wonder that children possess, but is often lost with age. They can also make interesting observations that may be profound, and can give scientists and biologists a sense of fulfillment. It is rewarding for them to see people interested and enthusiastic about a topic that they feel passionate about.

There are numerous examples of student activities associated with ATBI data collection, three of which are highlighted here. Students at Cherokee High School, many of them enrolled members of the Eastern Band of the Cherokee Indians, collected springtails in a remote area of the park that contained a unique soil type, and which therefore was thought to perhaps have unique species of springtails. Rather than ask the specialist to come collect in this area, the students learned the technique and performed the collection, and the samples were forwarded to him. A specimen was discovered in this collection that was different from thousands of others collected elsewhere. Another interesting example involves summer high school interns who were asked to periodically search in the Cataloochee area of the Park for additional specimens of an intriguing “junkyard bug” (green lacewing larva) which is known for carrying up to six different species of snails on its back as camouflage. The third example is from Great Smoky Mountains Institute at Tremont (Tennessee), which is an environmental education facility within the park. Since the ATBI began, we have developed a 6-year-long moth trapping project, using a specially designed non-lethal black light trap. Specimen identifications are verified by ATBI lepidopterists when necessary, but for the most part, identifications are done by the students, after which the moths are released. This project has produced records for over 600 moth species, including year-round adult flight phenologies and relative abundances, all from a site where we previously had no moth records. Over 120 species found and identified by students and their teacher-naturalists are new records for the park. The comprehensiveness of this project far surpasses any previous moth work conducted by park staff, university contractors, or other agencies in the history of the park.

By these examples, it is evident that students can easily follow instructions provided by researchers and thus can save the researchers time and money, and can provide them data that would not have otherwise been available. The most formidable challenge is fitting the right group to the right scope of project, as well as providing enough structure to maintain quality science products and life-changing experiences. There may be resistance among some scientists with regard to the quality of data that may be collected. However, scientists we have worked with have been very pleased with the quality of the work and data collection that students, as well as teachers and adult volunteers, have provided. Most are happy to work with students and look forward to the opportunity to do so. At times it can be a challenge to mesh the goals of science and education if the focus becomes too narrow—if it is trained on only part of the ATBI mission. Training scientists about the goals of education may be just as important as training educators about the goals of science.

With the dearth of taxonomic authorities for an increasing number of groups, efforts are being made at the Smokies to recruit serious students into this area of science. We have had some success in this area, with at least two Ph.D. candidates working on degrees in insect taxonomy. Additionally, several M.S. degrees related to taxonomy have been completed, and several more are in progress. We also have encouraged undergraduates to conduct taxonomic studies in the park. For example, at Warren Wilson College (a small liberal arts college in Asheville, North Carolina, with approximately 600 students in total), interested students have tackled one phylum of life—tardigrades, or “water bears” (microscopic crustaceans)—to work on, parkwide. When they approached ATBI coordinators wanting to participate, one of the few tardigrade experts in the U.S. was contacted to mentor them. We now know of 70 species of tardigrades from the park, whereas our previous knowledge was of only one species. This new number includes the discovery of 14 species new to science and one genus new to science. The students have presented their papers at professional meetings, including international tardigrade symposia, and now the Smokies, along with Poland and sections of Italy, are the best-studied sites in the world for this phylum of life.

Research Learning Center and other facilities

Hubs of science and education are being developed around the park. Although each facility has a different mixture of science and education, programs at these sites are integrated to further the educational mission of the ATBI and the National Park Service (NPS). These include the Appalachian Highlands Science Learning Center at Purchase Knob (North Carolina), Great Smoky Mountains Institute at Tremont (Tennessee), and the Twin Creeks Science Center (Tennessee).

The Appalachian Highlands Science Learning Center is one of a network of 17 Research Learning Centers throughout the National Park Service as of summer 2006. The mission of the Appalachian Highlands Science Learning Center is to increase the amount and effectiveness of research in the Appalachian Highlands Network of parks. The aim is to meet management needs while increasing public access to, understanding of, and appreciation of these research activities. Learning Center programs include research seed-grants for outside scientists, publications about research in the parks, internet databases for classroom use, teacher training seminars for elementary classroom teachers through college instructors, logistical support and housing for research needs, and education and citizen science programs for ages middle school to adult (Table 1). Much of the Learning Center's focus is on ATBI-related topics.

One on-going program that has been operated out of the Learning Center involves hiring high school interns from North Carolina to help conduct a variety of ATBI-related projects. Through this program, sponsored by the Burroughs Wellcome Fund, students work with visiting scientists to extend and intensify their projects, while also undertaking their own independent projects. Some of the projects have involved the following taxonomic groups: beetles, grasshoppers, gall-making insects, fruit flies, land snails, salamanders, planthoppers, bees and other pollinators, algae, slime molds, moths, ants, and bacteria. Collectively, they have found new mollusks for the state of North Carolina, collected

Table 1. ATBI program statistics from the Appalachian Highlands Science Learning Center at Purchase Knob, Great Smoky Mountains National Park.

	2005		2006	
	Number of Programs	*Number of Participants*	*Number of Programs*	*Number of Participants*
Teacher workshops	6	201	10	235
College classes	6	121	4	111
Adult programs	2	158	5	230
High School	12	574	8	134
Middle School	17	580	13	265
Totals	43	1,634	43	975

pollinators on rare plants, collected insects new to science, and filled in collection records for many different scientists.

Summary

Teachers, students, and volunteers are a crucial link between Great Smoky Mountains National Park to decision-makers and the public at large. They convey what they have learned about the biodiversity of the Smokies, and why it is important to protect the park. As "hands-on" participants in the ATBI, they are able to give examples of what they have seen and touched while out in the field with the researchers. They have heard directly from park staff and scientists about why we should care about the entire, complex web of life in the Smokies, and they can speak with fellow citizens and with politicians about resource allocation for research and about being good stewards of even the smallest creatures.

Education related to the ATBI benefits the park by helping people understand that in order to protect the park properly, we must first know what we are protecting. It is vital to have that basic information in order to carry out the mission of the National Park Service. The synergy of DLIA and resource educators depends on communication, goal setting, creativity, and the willingness to continue to create learning opportunities for the public. The science will provide the foundations of knowledge for years to come, and will generate new frontiers in education and resource management. Additionally, seeking that information is an excellent way to involve people in the community, thus creating stronger stewardship links.

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Implications of an ATBI for Reserve Stewardship

Keith Langdon, Peter White, and Becky Nichols

Introduction

SINCE THE 1980S, CONSERVATION HAS FOCUSED INCREASINGLY ON BIOLOGICAL DIVERSITY as a fundamental goal. We can trace this focus to many causes. Interest in biological diversity has been heightened by the rapid loss of tropical rainforests, which are great centers of diversity. Also, we have become more aware of the permeation of human effects: for instance, the spread of air pollution and exotic species into otherwise pristine areas, and an increase in habitat loss and fragmentation. Our measure of successful conservation has become not only the preservation of wilderness, but also the survival of all the plants, animals, and other species that are present within protected areas. It is also clear that some species migrate long distances, giving us a renewed sense of the interconnections that biodiversity represents and the critical role that protected reserves play.

Above all, perhaps, we should be reminded that our knowledge has a bias towards larger organisms and we are profoundly ignorant about the vast numbers of species, some of which play vital ecological roles: metabolic roles in decomposition and nutrient cycling, and regulatory roles in pollination and trophic interactions. Perhaps it is our ignorance and the sheer wonder of discovery that has raised enthusiasm for large-scale, taxonomically integrated biological inventories. But also, the species we discover will help us understand and defend conservation areas against threats. In a larger context, biological diversity has a fundamental value to ecological function and to humans: diversity supports future options in terms of the ability for an ecosystem to evolve and to adapt to environmental change. Genetic diversity is the basis for evolution and adaptation, and species diversity underlies the range of functions and responses at an ecosystem level. Further, when species loss occurs, it is irreversible because each species is the product of a unique evolutionary history that can never be repeated. Many factors thus underlie the excitement behind All Taxa Biodiversity Inventories (ATBIs) and the increasing interest in carrying them out in national parks and other conservation areas.

Species data

From the beginning of the Smokies' ATBI, park staff insisted that we needed four things:

- A comprehensive list of species for each group, with valid names and an understanding of where species fit in taxonomic hierarchies.

- An estimation of each species' relative abundance. Sampling protocols for some groups (e.g., forest litter organisms) may provide much better abundance measurements than others, but the ability to assign relative abundance is a goal for all species.
- Documentation of specific locality information. Once many points are accumulated, we can then attempt to associate each species with various habitat parameters, thereby allowing creation of a first-iteration distribution map for each taxon.
- Wherever feasible, sample in such a way as to provide information on the life history of each organism. A beetle collected in a flight intercept trap is a valuable record, but a beetle collected off of its plant host is a more valuable record, because it then allows both species and their relationship to be associated in the database.

One of the major tasks of an ATBI is to obtain specimen identifications. This is a massive task and should not be underestimated. At the Smokies, it is estimated that there may be 75,000 (+/– 25,000) multi-cellular species of organisms. For micro-organisms, the tally is predicted to be much higher (Seán O'Connell, personal communication). Species lists alone are of limited value in direct stewardship; however, managers of individual reserves should use their species lists to look past their own boundaries to assess their reserves' overall value to conserving regional, national, and global biodiversity in each species group.

From a strictly scientific viewpoint, we are learning a tremendous amount about certain species' ranges, habitats, and relationships with other species. Geographic analysis of multiple distributions can be used for activities such as protecting sensitive sites, locating monitoring activities at the most cost-efficient locales, properly tim-

Isotomurus philfrancisi, one of the springtail species new to science found by the ATBI. Photo courtesy of Ernest Bernard / DLIA.

Dr. Tor Tønsberg searches for lichens in the park. Photo courtesy of Rebecca Shiflett / DLIA.

ing control actions for pest species, displaying the varying intensities of ecological stressors across landscapes, and many other investigations. All of these activities are of value to park managers, heralding a new level of more intelligent stewardship of natural reserves. These data will also give the Smokies a strong foundation for advanced ecological research well after the ATBI project is completed.

Discovering exotics. Conducting an ATBI means sampling in every habitat and bringing in taxonomic experts who have wide experience in many other regions. A number of new exotics have been discovered this way during the Smokies ATBI, including, but not limited to, red imported fire ants *(Solenopsis invicta x richteri),* which are now being controlled but will affect many open-land native species; pear thrips *(Taeniothrips inconsequens),* a European insect that feeds on many North American trees, but in the last 20 years has devastated sugar maples in New England; giant resin bee *(Megachile sculpturalis),* which is a primary pollinator of kudzu in its native region in Asia; Klamath weed beetles *(Chrysolina quadrigemina),* which have suppressed introduced St. Johns worts *(Hypericum* spp.) in the West, but may affect two rare narrow endemics, *Hypericum mitchellianum* and *H. graveolens*, in the park; and Chinese jumping worms *(Amynthas hilgendorfi),* which are devouring forest duff in an area with concentrations of rare plants. Each of these ATBI discoveries has resulted in some monitoring, management, or research action. ATBIs will lengthen the list of known species-specific threats by exotics in each reserve, but we are better off finding them in their incipient stage of invasion, rather than later when fewer control options are available.

"Spin-off" science

No one can predict the number or type of threats that will be faced by a park or

Collecting a soil sample under the falls during a 2006 beetle blitz at White Oak Sink. Photo courtesy of Charles Wilder / DLIA.

reserve in the future. Although not a goal of the inventory, monitoring of biological resources from a well-documented ATBI baseline is not only possible, but is virtually assured in future years as changing circumstances require re-measurements of specific resources. The excellent long-term monitoring program currently being established agency-wide by the National Park Service (www1.nature.nps.gov/protectingrestoring/IM/vitalsignsnetworks.cfm) is well conceived, peer reviewed, and necessarily expensive. The biological monitoring components that are quantitatively monitored are therefore a very narrow selection of park "vital signs." These park "vital signs" usually include at least some species- or population-level monitoring in park units, but expense keeps the number of species and sites monitored very low relative to the number of total species in the park or reserve.

It is assumed that the confidence placed in monitoring results can be increased with the number of years of data collected. However, stressors that were targeted 10 or 15 years beforehand when a monitoring program was planned may not have the flexibility to be decisive or even minimally inform managers confronted with a new threat. A completed ATBI means the broadest possible palette of baseline species data is available for special or periodic re-sampling, when needed. Having a known status for a species, or group of species, or site in a reserve at a known period in the past, is invaluable when a future exotic invasion, proposed project impact, or other disturbance occurs. This makes a well-designed monitoring program based on "vital signs" and an ATBI complementary—a data "hedge" against the many unknowns parks and reserves are facing and will continue to confront in the foreseeable future.

Another example of "spin-off" science is that over 1,000 species of moths and butterflies in the Smokies have had their mitochondrial DNA sequenced and indexed as part of the ATBI. The other 600 known species of Lepidoptera will be added to this database in the near future. Now the park can identify most larvae, making a number of important and previously impossible ecological studies possible. These include plant host–herbivore studies, pollinator studies, bird diet studies, etc. If researchers writing proposals can come to a protected reserve where these data are available already, the reserve becomes much more attractive, and ATBIs become a springboard for advanced research projects in the future, which in turn will benefit the reserve's stewardship.

Next steps

In our "sound bite," scorecard-oriented society, we usually get asked how many new species we have found, but even if not a single new species or new record would have been found, the discovery of hundreds of thousands of known points for known species would make the ATBI a worthwhile endeavor for stewardship and protection purposes. One of the next hurdles in the Smokies ATBI is to develop probability distribution maps of park species. Most threats to natural resources are not uniformly distributed over a reserve of any size, and neither are the resources that are jeopardized. This is one reason that a priority for many resource stewards is to obtain high-resolution species distribution maps in a GIS where they can be overlain with many other data themes. When distributions are mapped, analysis with a GIS can be used to

A syrphid fly lands on a turtlehead bloom growing along the Appalachian Trail between Clingman's Dome and Newfound Gap. Photo courtesy of Charles Wilder / DLIA.

determine which environmental factors they are associated with, such as temperature, geochemistry, solar aspect, moisture, etc. To start, rare, listed, commercially collectable, and endemic species in the Smokies will be targeted, but eventually all species for which we have enough point locations will be included. This will then allow us to develop predictive models of the responses of individual species, guilds, or communities of species to threats (e.g., global warming, invading exotics, loss of integral habitat along boundary, etc.) or management activities (e.g., prescribed fire). This will be a major step forward for stewardship.

Summary

Every discovery in an ATBI immediately results in value to stewards of the reserve. Not just species new to science and new records for the reserve, but even new locations for common species help in the development of more accurate phenological, geographic, and ecological data products of those species. These values accrue as the project proceeds to completion with comprehensive public involvement in real scientific discovery, "spin-off" scientific activities, and a superior understanding of the complex ecological processes that drive and sustain every nature preserve.

Several units of the U.S. National Park System, as well as some private and state natural areas, have either started ATBIs, or are planning to do so (see Langdon, Parker, and Nichols, this volume). All of these reserves share an interest in science and education, but they also recognize that they need much more detailed information about their natural resources—even if the reserves were established over a century ago. Because reserve staffs constantly have to make decisions about how to assess the impacts of various operations (e.g., development proposals, site modifications, prescribed burning, pesticide applications, recreational uses, etc.), information about where species occur, how rare or abundant each is, and basic information about the species' life history is of the utmost importance.

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Scientific Findings, Success Stories, Lessons Learned, and an Alliance of ATBIs

Keith Langdon, Charles Parker, and Becky Nichols

Scientific findings

The most frequently asked question about the All Tax Biodiversity Inventory (ATBI) is "How many species have you found?" This is to be expected, as the ATBI is an inventory. The answer is presented in the "taxa table" (Table 1) below, and, more currently, on the Discover Life in America (DLIA) website (www.dlia.org/atbi/new_science/discoveries.shtml). However, when we are asked this question we always qualify our answer by stating the last date the table was updated. This is because the numbers change so frequently that keeping up is a major difficulty, but one we are pleased to be faced with. Since this article was written, bio-quests have been held, scientists have visited the park independently to collect specimens, and additional samples have been processed from the pilot study backlog. So the answer has changed since the table below was produced—of that we can be certain.

Success stories

Professional recognition. The National Science Foundation (NSF) is the premier funding agency in the United States for scientific research. Traditionally, proposals submitted to NSF for funding have a success rate of less than 30%. ATBI cooperating scientists have received funding from NSF for five proposals specifically aimed at research in association with the Smokies ATBI. These proposals involve pyrenomycetes (wood-inhabiting fungi); agarics (mushrooms and their relatives); algae, diatoms, and cyanobacteria (blue green algae); beetles; and the tree canopy biota. These grants total more than $1,500,000. The willingness of NSF to fund proposals to conduct research associated with the ATBI indicates that the reviewers are impressed with the scientific credentials of the scientists and the quality of their research, and also recognize that the ATBI is a legitimate scientific undertaking deserving of financial support.

From the beginning, the ATBI has been an international activity. Scientists from Costa Rica and Canada attended the first organizational meeting in 1997, and since then scientists from around the world have worked with us in conducting the ATBI. In addition to Canada and Costa Rica, scientists from France, Italy, Norway, Russia, Spain, Sweden, and Ukraine have either visited the park to conduct studies, or have identified ATBI material we provided them.

Reducing the taxonomic impediment. As detailed in Parker and Bernard (this volume), the taxonomic impediment is the shortage of authorities to meet the world's needs for taxonomic services, not just in tropical countries with rapidly disap-

Table 1. Discoveries of the Great Smoky Mountains National Park All Taxa Biodiversity Inventory (ATBI), as of 17 August 2006. "New to Science" species have never been identified anywhere in the world before the ATBI. "New to Park" species have never been identified in the park before the ATBI (i.e., they are new geographic records). "Total New" is the sum of the "New to Science" and "New to Park" columns. It is the total number of species that were not known to exist in the park prior to the ATBI.

TAXON	New to Science	New To Park	Total New
Microbes			
Archaea	6	1	7
Bacteria	92	59	151
Microsporidia	1	4	5
Protozoa	2	14	16
Slime molds			
Dictyostelids	10	8	18
Protostelids	8	12	20
Myxomycetes	2	130	132
Algae	67	528	595
Plants			
vascular	0	47	47
non-vascular	0	9	9
Fungi	25	347	372
Lichens	10	83	93
Nematomorpha (horsehair worms)	0	5	5
Mollusks (snails, mussels, etc.)	6	111	117
Annelids			
aquatic oligochaetes	0	17	17
earthworms	4	7	11
leeches	0	8	8
Nematodes (roundworms)	1	6	7
Tardigrades (waterbears)	14	56	70
Arachnids			
spiders	40	237	277
mites	6	47	53
ticks	0	6	6
Crustaceans (crayfish, copepods, etc.)	27	65	92
Diplopoda (millipedes)	1	1	2
Pauropoda (pauropods)	20	27	47
Symphyla (symphylans)	2	0	2
Protura (proturans)	10	5	15
Collembola (springtails)	60	116	176

Table 1 (continued).

TAXON	*New to Science*	*New to Park*	*Total New*
Diplura (diplurans)	5	2	7
Microcoryphia (jumping bristletails)	1	2	3
Ephemeroptera (mayflies)	4	11	15
Odonata (dragonflies, damselflies)	0	29	29
Orthoptera (grasshoppers, crickets, etc.)	0	45	45
Blattaria (cockroaches)	0	6	6
Plecoptera (stoneflies)	3	5	8
Psocoptera (barklice)	0	24	24
Pthiraptera (lice)	0	21	21
Hemiptera (true bugs, hoppers)	4	148	152
Neuroptera (lacewings, antlions, etc.)	0	23	23
Megaloptera (dobsonflies, alderflies, etc.)	0	1	1
Coleoptera (beetles)	34	1,200	1,234
Mecoptera (scorpionflies)	1	8	9
Siphonaptera (fleas)	1	9	10
Diptera (flies)	50	158	208
Trichoptera (caddisflies)	5	72	77

Table 1 (continued).

TAXON	New to Science	New to Park	Total New
Lepidoptera (butterflies, moths, skippers)	72	688	760
Hymenoptera (bees, ants, etc.)	27	60	87
Vertebrates			
amphibians	0	2	2
reptiles	0	2	2
fish	0	4	4
mammals	0	1	1
birds	0	1	1
TOTAL	621	4,479	5,100

pearing rain forests, but also in temperate areas such as North America. More students need to be encouraged to study systematics, and more opportunities for professional careers in systematics need to be developed. Thus, we are extremely pleased that the ATBI has contributed to reducing the taxonomic impediment by directly influencing students to pursue advanced degrees in taxonomy. Currently, there are at least 12 students who have worked on aspects of the ATBI during their degree programs, and may eventually make the career choice of becoming taxonomists. Two examples are Ian Stocks and Matthew Petersen. Stocks served as the principal technician on the ATBI pilot study in the Smokies and was responsible for plot maintenance and sample retrieval and processing. Although he came to us with a Master's degree and a professed interest in technical work with no desire to pursue a Ph.D., his experiences with the ATBI ultimately led to a change of heart and he is now is pursuing a doctorate in insect systematics at Clemson University. Petersen began working in the park as a field technician in the inventory and monitoring program. Like Stocks, he professed no interest in pursuing an advanced degree; however, he worked in the park during the time that the ATBI was being formulated, and eventually decided to take advantage of the opportunities it presented. Petersen currently is studying crane fly systematics at Iowa State University for his Ph.D. These two students are likely to be involved for years in working out the systematics of their two groups, and assisting other reserves conducting inventories.

Protecting the park. As data are accumulating from the ATBI, it has become a standard source of information for environmental assessments and the several full environmental impact statements (EISs) that the park has been deeply involved with in recent years. Results from comprehensive species inventories were instrumental in keeping critical resource sites within the park during a highly controversial and political land trade. Results are also influential in other EISs that are still going through the National Environmental Policy Act (NEPA) process. Routine environmental compliance is also better informed, and we are becoming better able to craft viable alternatives to initial proposals.

Awareness. All methods of communication are important, but we have emphasized the utility of the DLIA website, www.discoverlifeinamerica.org. A wealth of information is now presented here, and recently the ATBI database has come online and is linked from this site. Accessing the public version of the database, which has had rare, sensitive, and commercially collectible species locations removed, allows people to find on-going reports of georeferenced data.

The thrill of new discoveries has helped encourage local and regional citizens and students to become involved in the ATBI. But beyond the adventure of field exploration, there is a sense that the surrounding communities value the park more now, perhaps because of species that they may have helped discover. There has always been a "pride of place" sentiment around the Smokies, and that uniqueness now has deepened. It is difficult to quantify that change in the public's valuing of the park, but other parks and reserve staff who have visited and experienced ATBI activities have been moved to initiate their own ATBI projects based on that perceived increase in support.

Lessons learned

When the Smokies ATBI began, then-Superintendent Karen Wade observed that the undertaking was overwhelmingly an exercise in social engineering. With over 200 scientists (often assisted by students and technicians) and even larger numbers of citizen-scientists working on every facet of biodiversity in the park over the past eight years, great attention to detail is required to ensure that everything goes smoothly. While many things have worked extremely well, not everything has. We have highlighted some of the difficulties encountered during the pilot study that led to changes in the manner in which the structured sampling will be conducted in the future. Below we reiterate those points, and provide some guidance based on other lessons learned at the Smokies and at other ATBI projects that we are aware of.

- Begin with data management. Develop a data management plan that your area and your cooperators will agree to use. Require that people populate the database with their findings. However much you devote to data management, it will not be enough. But your program will only be as successful as your data management strategy.
- Taxonomists are a scarce resource. Do not waste their precious time. They may be willing to donate their services, but it should not be expected of them. Your ability to secure funding will influence your ability to secure taxonomic assistance.
- Collaborating scientists face their own bureaucracy in their home institutions. Do what you can to reduce agency bureaucratic burdens on them when they agree to work with you.
- Make sure there are social opportunities for cooperators. Taxonomists normally work independently, unlike ecologists who often work tribally, and volunteers who work best when positive reinforcement is optimized. Much innovative collaboration will result if social opportunities are encouraged.
- It is easy to over-collect specimens (see Parker and Bernard, this volume), especially during bio-blitzes. It becomes expensive to handle, to ort, and, especially, to identify specimens,

and then to process them for museum use. Avoid collecting just because you can, or because it is part of a public event; it does no good to have specimens in unsorted lots in storage for years.

- It is important when relying heavily on volunteers to conduct critical aspects of a complex activity to match the right volunteer with the right position. In the beginning of the ATBI, several scientists volunteered to serve as Taxonomic Working Group coordinators, and in most cases, these individuals have worked well. However, some were poorly suited to the tasks of coordinating fellow scientists (an activity often compared with herding cats) and it was necessary to find replacements for them. Recruit broadly, and then check with folks you trust who know the person. Some personality types are great enthusiasts but may not be good coordinators, or do not have a good track record on finishing things. (Quote from the first ATBI conference: "90% of life's successes and failures is due to personalities, the other 10% is due to weather.")
- Bio-blitzes and other large, intensive field collection events are fun, generate a lot of involvement by scientists and volunteers, and create positive popular press. However, it is easy for such activities to result in very little useable data when all is said and done. Not all field scientists understand how important it is for stewardship purposes to have accurate map coordinates for all samples. Things may be too rushed, and too many logistical issues may come up in the day or two that most blitzes run that will ultimately prevent you from assuring that the results are meaningful. These difficulties can be prevented with sufficient planning.
- Plan much more than you think you need for quality assurance in the data stream.
- Have designated people serve as specimen and specimen lot labelers so that no material goes unlabeled.
- Provide staff or volunteers trained in global positioning system (GPS) use and who know your spatial data accuracy requirements to assist visiting researchers.
- Make interactive mapping programs available for collectors to use in order to ensure the accuracy of collection locations, or have topographic maps available on which collection locations can be verified.
- Place someone in charge of checking all data that comes in, throughout the course of the event.
- Scientists appreciate decent lodging facilities for themselves and especially for their students. It also is desirable to provide a central place where groups can work together. If you treat them well, they will tell their network of colleagues, and perhaps they, too, will want to help out the next time.
- Everyone needs to be involved in keeping costs down, and being alert for new funding opportunities.

An Alliance of ATBIs

What is the most ecologically diverse nation on Earth? The answer depends on how you measure diversity. When the 14 non-marine biomes of the world are mapped, the U.S., with about 6% of the world's land area, has 12 of the 14 biomes—more by far than any other country (Udvardy 1975). Similarly when Bailey's ecoregions are mapped world-wide, the U.S. again has the most number of regions (Bailey 1989). In addition, the U.S. contains about 10% of the world's freshwater wetlands (Aselmann and Crutzen 1989).

But these are coarse filters and the U.S. would presumably not fare nearly as well as many other countries when other measures, such as species richness are used—or would it? Again, it may depend on what you measure. Certainly at the Smokies we, and especially our cooperators, have been surprised by the number of species we have discovered so far. In some groups, the number of species in the park rival or exceed the numbers in tropical rain forest areas. But in a larger sense this kind of comparison is so superficial that it misses the point: almost all of the species in the U.S. are different from those elsewhere, and deserve to be discovered, identified and thereby be protected in their own right.

How will we ever know what is natively found if we never undertake to sample this country? We now briefly outline a plan to do just that. Imagine an array of national parks, state parks or reserves, and other permanently protected areas organized for the purpose of undertaking ATBIs, which are roughly stratified across some eco-regional classification. That is, the deserts of the Southwest, grasslands in mid-country, polar areas, tropical islands, marine and estuarine areas, temperate coniferous and deciduous forest areas, and all the other major and minor "eco-regions" of the U.S. (see Stein et al. 2000). The total area of the U.S. included in these intensively sampled sites would be far less than 1% of the land area, and, as we learn in other articles in this volume, actual field samples in each area will be far less than 1% of the reserves being sampled. Still, this would give us tremendous insight into the biodiversity of those reserves, those ecoregions, the country, and the Earth as well.

This is what the Alliance of ATBIs is about. At this time, 19 reserves have begun exploring formally creating such an alliance (Figure 1). This includes 12 national parks, five Tennessee state parks, New York's Adirondack Park, and Nantucket Island, a Nature Conservancy/Massachusetts preserve. This alliance has come about because of the many inquiries we have received about how the Smokies ATBI operates and how it may be implemented in other places. Each ATBI, although individually managed, would subscribe to a minimum number of common-sense standards in communications, data collection and management, results-sharing, joint fund-seeking, etc., and agree to actively participate in the governance of the Alliance. The professional staffs of each reserve must voluntarily buy-in to the core principles that guide the project.

An Alliance office will need to be created to coordinate regional and national funding proposals, set up mechanisms to increase scarce taxonomic resources, operate publications and communications links and outlets, and other tasks collectively assigned to it. Funding for each project could potentially start with a local or regional source of donated funds, and professionals and volunteers in the area can be recruited to help organize and conduct operations. Major funding from corporations, foundations, and agencies in the form of grants, cost-sharing, and other funding mechanisms will be sought for multiple projects by the Alliance office, and groups

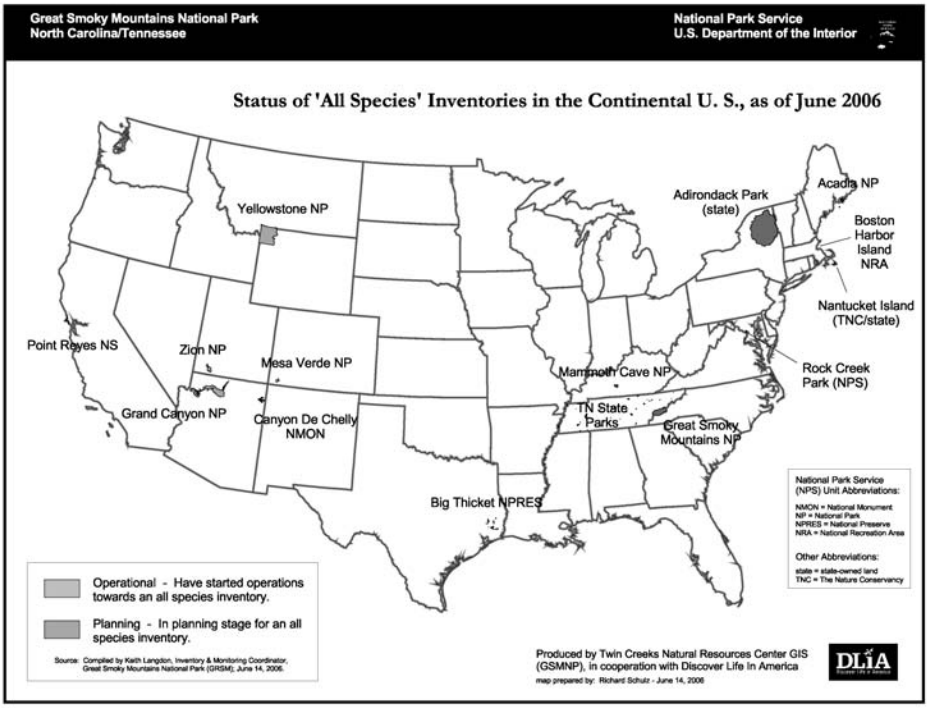

Figure 1. The Alliance of ATBIs.

of scientists should be encouraged to apply to their traditional grant sources, such as the National Science Foundation.

An ATBI is a comprehensive scientific inventory of biological diversity that includes citizen participation. It is more than a count of species, as it also highlights the relationships within an ecosystem and emphasizes how such relationships can inform and guide management decisions regarding the conservation of ecosystems. An alliance of regionally or locally based ATBIs takes the next organic step in understanding the ecology of unique ecosystems within North America and enhances local citizenship participation and stewardship of those systems. An alliance of ATBIs provides a viable means to share that understanding of organisms and their environments and to share lessons learned in developing, managing, and funding such inventory efforts. By getting the local and regional public involved in the science, the reserves each build stronger constituencies for their own long-term protection, and individually and collectively make a major change in America's connections with nature, and science.

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