



Biodiversity Discovery

A Foundation for Resource Protection and Stewardship

Natural Resource Report NPS/NRPC/BRMD/NRR—2010/278



ON THE COVER

Searching for marine life collected in the waters off Elliott Key in Biscayne National Park at the 2010 Biscayne BioBlitz, offered in partnership with National Geographic NPS/Thomas Strom

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Executive Summary

The National Park Service is charged with protecting the diversity of living organisms (i.e., biodiversity) found within its lands. Yet, as the National Park Service nears the beginning of its second century, estimates indicate that as many as 80–90 percent of the species in parks are undiscovered. This gap in knowledge makes it impossible to protect living resources from emerging threats—such as climate change, invasive plants and animals, disease, and human population pressures—or to keep ecosystems intact. To help address this gap, the National Park Service is undertaking a new effort, Biodiversity Discovery, to both document the diversity of life in parks and ensure the future of park scientific study by engaging the next generation of scientists, educators, and park supporters.

The first Biodiversity Discovery effort began as the All Taxa Biodiversity Inventory in the Great Smoky Mountains in 1998. Since then, many parks—large and small, naturally or culturally oriented—have begun their own Biodiversity Discovery activities; as of 2010, more than 40 national park units had planned or conducted them. While biodiversity inventory is well-known across the National Park System, Biodiversity Discovery captures both the scientific and stewardship goals of conservation. Parks often use different names for their Biodiversity Discovery activities, but they share several common goals: (1) to gain knowledge about little-known groups such as insects, fungi, bacteria, and microscopic life—organisms that are key to ecosystem integrity and also to responsible park management; (2) to engage the public, young and old, and create a cadre of park supporters who believe science is relevant; and (3) to present biodiversity information to park managers in an organized way that reveals biological patterns at a broader regional, or even national, scale.

The benefits of Biodiversity Discovery are multiplicative across different areas:

- Benefits to park management include the ability to make sound, long-term decisions with increased species knowledge and support from partnerships built through Biodiversity Discovery. Also, Biodiversity Discovery will support existing National Park Service Inventory and Monitoring Networks, Research Learning Centers, and Cooperative Ecosystem Studies Units.
- Benefits to science include the discovery of species—sometimes thousands—that are new to the park or even to science. Some such species may reveal key shifts in park ecosystems as climate change, invasive species, and other threats occur.
- Benefits to education include being able to provide hands-on, experiential learning environments that improve scientific literacy by making classroom lessons come alive, and that inspire environmental awareness that students may not gain anywhere else.
- Benefits to society include increased awareness of the local ecosystem in which participants live and a re-engaged sense of relevancy to science and stewardship.

With the diverse benefits of Biodiversity Discovery activities, more parks across the country are incorporating them as key parts of their resource management, science, and education programs. However, parks do not currently have national coordination, funding, or support for these efforts, which often puts small or culturally based parks at a disadvantage. Faced with these challenges, parks are proposing a nationally coordinated effort to help initiate and continue Biodiversity Discovery. Areas of coordination would include sharing data and taxonomic expertise, developing a clearinghouse of information for planning events, and using the information obtained to inform sound management decisions. This national umbrella of support would encourage cooperation while keeping intact the grassroots initiative that has proven so successful.

Fulfilling the conservation mission of the National Park Service in the face of new threats requires that the Service embrace new approaches to science. Biodiversity Discovery activities are already successful

scientific tools at many parks and have emerged as vital efforts to ensure preservation of our living resources by combining sound science and public passion.

Biodiversity Discovery in the National Park Service

The National Park Service began because explorers, artists, politicians, and everyday citizens recognized the value of America's undeveloped wildlands. Today, we recognize not only the value of these lands but also the value of their biological diversity ("biodiversity").

Our parks are home to plants and animals that have disappeared in other parts of the world because of development, habitat fragmentation, and resource overuse. Our parks serve as key areas to conserve biodiversity as climate change, human development, and invasive species alter the landscape. Preserving species small and large—from lichen to polar bears—is a National Park Service (NPS) mandate. Preserving our biodiversity also ensures that future artists, students, and scientists will experience these lands as park founders did long ago.

Biodiversity Discovery, the term for a variety of efforts to discover and document the living organisms in our parks, has emerged as the foundation upon which parks can build sound, long-term plans for management and preservation. While biodiversity inventory is a well-known idea, Biodiversity Discovery combines scientific and stewardship goals. Unlike past inventory studies, or

inventory and monitoring efforts that track known species over time, Biodiversity Discovery focuses on little-known groups such as insects, fungi, bacteria, and microscopic life—organisms that we are beginning to understand as key to ecosystem integrity and resilience. Already, more than 40 park units across the country have planned or conducted different types of Biodiversity Discovery activities. These include multi-decadal All Taxa Biodiversity Inventories (ATBIs) to document all species in a geographic area, BioBlitzes that search for species within a given timeframe (often a weekend), and more targeted activities such as afternoon Bioquests to collect rare plants. The variety of Biodiversity Discovery activities reflects the diversity of parks themselves—their ecosystems, resources, and science goals.

Also diverse are the participants in Biodiversity Discovery. Many parks have

Biodiversity Discovery events focus on little-known groups, such as Hemiptera ("true bugs") at the 2008 BioBlitz at Acadia National Park. NPS/Karen Lanier.



Citizen scientists, such as these participants learning about spiders from a wildlife biologist at Acadia National Park's Spider Blitz, are an essential part of the Biodiversity Discovery effort. NPS/Todd M. Edgar.



invited the public to help with the daunting task of discovering new species across often vast landscapes. Across the country, people are pulling on boots and heading out into the fields, forests, tidepools, and caves of national parks to discover biodiversity. Sometimes it is barely dawn when they unfurl mist-nets to catch songbirds; sometimes it is almost midnight when they gather shimmering moths by mercury vapor lamp-light. The people involved range in age from toddler to retired. They may be “citizen scientists” new to the field, PhD experts with decades of specialization, or national park scientists responsible for protecting biodiversity in the parks. Sometimes, all of these people work shoulder to shoulder on a biodiversity team, whispering excitedly because they have spotted a living thing that they have never seen before.

As different as the Biodiversity Discovery activities are, and as varied as their participants may be, all of these emerging efforts have a common goal: to discover and document the species the National Park Service is mandated to protect, and to do so by engaging the public directly in this discovery. It is likely that 80–90 percent of the species in parks are undiscovered, yet the NPS is charged with protecting all of them. The collective efforts of Biodiversity Discovery in parks of all sizes and types—including urban parks, large undeveloped parks, and those with a cultural focus—help us understand and protect our country’s incredibly varied natural heritage. By engaging the public in these efforts, people become immersed in the natural wonder of their parks and create lasting connections to our parks’ special places and resources.

National Parks and the Roots of Biodiversity Discovery

The National Park System encompasses approximately 83.6 million acres of land. From the largest—Wrangell-St. Elias National Park and Preserve in Alaska, at 13,200,000 acres—to one of the smallest—Tupelo National Battlefield, at 1.0 acre—each is home to amazing levels of biodiversity (National Park Service n.d.).

No park unit represents a static ecosystem. Habitats constantly shift with fires, falling trees, severe weather, and other disturbances, and the species within them adapt. However, we now are experiencing ecosystem disturbances of a greater magnitude. Through the next century, the world's ecosystems will likely face major changes due to:

- *global climate change*, which will shift habitats and result in new plant and animal community assemblages (Burns, Johnston, and Schmitz 2003), as well as intensify weather events;
- *new development of cities, roads, and energy facilities* that will change and fragment the landscape, including habitat linkages and wildlife movement corridors;
- *growing human populations*, which will directly and indirectly put pressures on protected areas, including increased use,

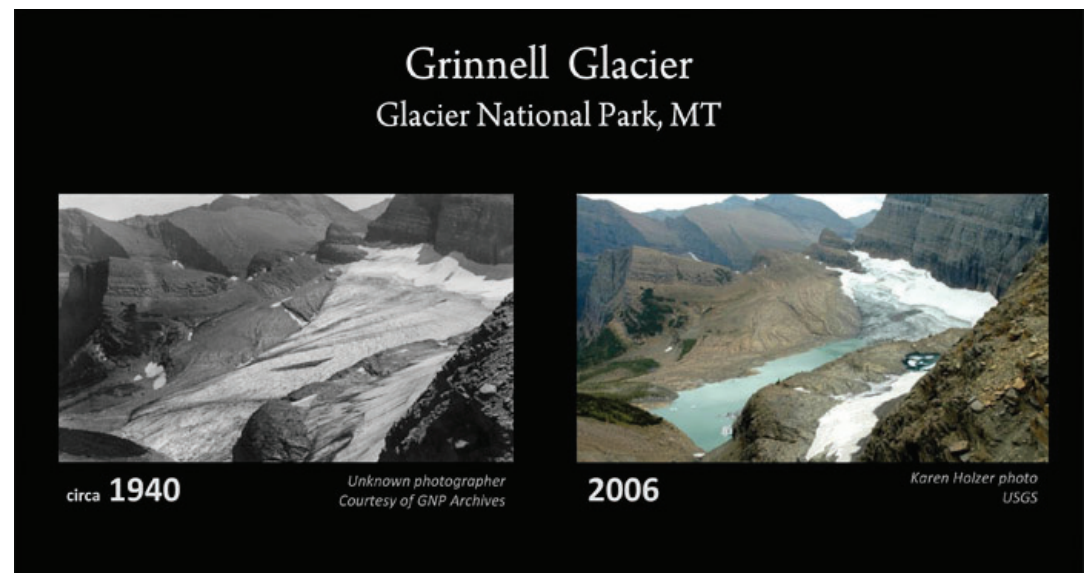
loss of water, and air, noise, and light pollution, and other new resource management challenges; and

- *continued introductions of non-native, invasive pests and diseases*, which will change species composition of ecosystems and may wipe out certain species entirely.

National parks are not immune to many of these changes, but they exist as habitat remnants where some of these pressures may be lessened. They often provide the only remaining habitat for plants and animals pushed out of their historic ranges, so they become genetic refuges and serve as important living laboratories for scientists and educators.

We have already seen a dramatic example of ecosystem loss following Hurricanes Katrina and Rita in 2005. One NPS resource manager said that we learned from the experience of parks in Louisiana and Mississippi: they didn't know what species they had, and after losing entire habitats in the storms, they may never know. Currently most NPS staff don't know most of the species that live within their Park's boundaries. That makes effective adaptive management very difficult. It also means that we will not know what is lost as ecosystems inevitably change.

National parks are facing challenges that require thorough knowledge of the species they contain. Climate change, for example, is shifting habitats through changes like shrinking glaciers. These images of Grinnell Glacier in Glacier National Park show a dramatic increase in the size of Upper Grinnell Lake as a result of melting ice. U.S. Geological Survey Northern Rocky Mountain Science Center/ Glacier National Park archives [left] and USGS/Karen Halzer [right].



Our national parks offer an ideal environment in which to discover biodiversity at this critical time in history.

The roots of today's Biodiversity Discovery can be traced back to the exploratory zeal of Lewis and Clark, who, in the early 1800s, made the "first systematic reports, based on scientific measurement... of the Missouri River—not only its course, but its flora and fauna." From the Rocky Mountains and Pacific Northwest, they added "at least 120 mammals, birds, reptiles and fish, as well as at least 182 plant species" to known lists (National Park Service 2007b). In the twentieth century, scientists realized the value of such species lists for long-term, proactive conservation. More recently, the focus has shifted to lesser-known species. A scientist at Yellowstone National Park noted that by the time we see changes in large, iconic animals, "there's probably more going on behind the scenes... some change, or something wrong below the level of the large ungulates." Knowledge of the smallest living things—insects, in this case—might be the key to future preservation of all species. It is in those knowledge gaps—the insects, bacteria, fungi, and other miniscule organisms—that we have the greatest opportunities to learn.

In the past, scientists have conducted partial inventories of some of these lesser-known groups of plants and animals in a few national parks. In Acadia National Park, for example, William Proctor made collections and notes from 1918 to 1945, and the park uses his species lists as a baseline with which to compare the life in the park today (Acadia Partners for Science and Learning

2009). Studies this extensive are rare, however, and few of these inventory efforts had the goal of developing a comprehensive list of *all* living things within a park's boundaries.

A major step forward in our knowledge of park life occurred with the establishment of the Inventory and Monitoring (I&M) Program and subsequent funding increases that came with the Natural Resource Challenge, beginning in Fiscal Year 2000. Through the establishment of regional networks, I&M activities have supported focused inventories of many species groups, including extensive efforts to document vascular plants and vertebrates in many of our parks. A systematic effort to identify and prioritize "vital signs" of ecosystem condition and to monitor selected vital signs in parks and across park networks to evaluate the health of biological and physical systems upon which living communities depend is another part of this program. Both the inventory and monitoring efforts that make up the I&M Program have been crucial to recognizing and beginning to understand our dynamic park ecosystems over time.

The sheer number of park inventories and ecosystem vital signs far exceed the capacity of the I&M Program alone. Also, to ensure statistical rigor and long-term support for consistent and systematic field data collection, the I&M Program must focus its resources on a small but well documented set of vital signs and inventory priorities.

Fungi found during Point Reyes National Seashore Mycoblitz, 2007. Photo courtesy of the Bay Area Mycological Society.

Cooperators sampling macroinvertebrates at Fredericksburg and Spotsylvania National Military Park as part of the I&M effort. NPS/James Comiskey.





Consequently, most I&M networks are unable to embark on continued Biodiversity Discovery efforts without jeopardizing other important priorities. However, it is clear that parks still need more biodiversity inventories and better data on species distributions, particularly for lesser known groups such as invertebrates, fungi, and non-vascular plants. This is especially true as natural areas face more pressure from climate change, invasive species, and habitat fragmentation. Biodiversity Discovery events offer unique and valuable opportunities to complement the success of I&M efforts and help fill unmet—yet critical—inventory needs. Indeed, parks stand to learn enormous amounts about their natural resources, ecosystem functions, and vital sign trends by combining long-term monitoring, targeted inventories, and Biodiversity Discovery events.

Biodiversity Discovery emerged as a tool to complement the efforts of the I&M Program by filling critical gaps that could not be accomplished due to limited time, funding, and resources. It also emerged as a new way to involve non-park groups in discovering life. The first such Biodiversity Discovery program began at Great Smoky Mountains National Park in 1998, with coordinated efforts by the park and its non-profit partner Discover Life in America (DLIA). Based on biologist Dan Janzen's efforts to inventory and document locations for all living things in Costa Rica, the effort was called the All Taxa Biodiversity Inventory (ATBI), and it was (and still is) an effort to relentlessly search for new species in unexplored areas and at unexplored

scales. More than ten years later, ATBI activities at the Smokies have resulted in the discovery of over 900 species new to science and over 6,500 species new to the park. The Smokies' efforts have ranged from more than 20 BioBlitzes and dozens of Fern Forays—events for the general public run by taxonomic experts—to backcountry expeditionary groups of one or two top scientists in their field. The Smokies ATBI has, in turn, motivated other parks to take on their own Biodiversity Discovery activities—sometimes full ATBI efforts to discover all species within a park's boundaries, and sometimes shorter or smaller events as time and funding permit.

The Smokies ATBI efforts not only have resulted in a list of new species, but also have documented many more locations of all species, leading to a geo-referenced understanding of biodiversity distribution throughout the park. This has helped managers understand the distributions of such common species as mosquitoes and copperhead snakes, both of which had never been comprehensively searched for, although both have implications for human health.

What the ATBI at Great Smoky Mountains did for management at one park has been notable, providing scientists with a greater knowledge of connections between living organisms and guiding further in-depth research with partner universities. What the ATBI and Biodiversity Discovery initiatives as a whole are doing for the National Park Service is exceptional: many parks have adopted the idea that discovering biodiversity not only adds names to a species list and

points to a map, but also is crucial to fulfilling the NPS mission.

Parks that have taken on Biodiversity Discovery activities range from the largest, best-known parks, such as Yellowstone and Yosemite, to the smallest, cultural or urban parks, such as George Washington Birthplace. This is important because every National Park System unit, no matter its size or whether it was preserved for unique landforms or cultural value—represents a different collection of fauna and flora and represents different degrees of human alter-

ation of the habitat. As a manager at George Washington Birthplace said, we need to ensure that the National Park Service views cultural parks as important reserves for biodiversity. Parks of all sizes have natural resources they are mandated to manage, yet they can't effectively and responsibly manage what they don't know they have. As a whole, these programs comprise a national Biodiversity Discovery effort that is unprecedented in scientific scope and public engagement. Table 1 showcases a few of these efforts.

Table 1. Biodiversity Discovery Activities in the National Park Service

Park ATBIs	Park BioBlitzes
Boston Harbor Islands National Recreation Area began an ATBI program in 2004 with help from E.O. Wilson, a preeminent biologist, and invertebrate experts from the Harvard Museum of Comparative Zoology. Wilson coined the term "micro-wilderness" to describe the diversity of life on small, isolated islands, and since then, hundreds of students have ventured onto the islands during BioBlitzes to collect invertebrates. Students who took part during one soaking, chilly weekend wrote that they loved the experience: "It was cool," one girl wrote, to do "an inventory on Thompson Island. Not very many people do that, and it was really cool to look for bugs in a place that's not the same as where you live." Scientists scan high resolution images of every species found, which means that more than 1,300 intriguing images are available in an online database. When the Harvard partnership ends in 2010, individual researchers will continue to search for, and add to, knowledge of botanical and animal biodiversity as part of the park's ATBI. Big Thicket National Preserve held their ATBI kick-off event in 2006. Big Thicket has a very supportive, permanent, non-profit partner (Big Thicket Association) dedicated to their park. They understand their ATBI efforts are the beginning of a continuous, multi-year (or even decade) collaboration between: the public, Taxonomic Working Groups (TWiGs) of experts in their field, park staff, academic institutions, and independent researchers. The topics that these varied biodiversity seekers cover are also broad, encompassing 12 groups, so far, from amphibians to orchids to fungi. In the West, 16 protected areas formed a collaborative group called the Colorado Plateau ATBI. Coordinated by Dr. Neil Cobb, director of the Merriam-Powell Center for Environmental Research in Arizona, the Colorado Plateau parks are well organized via a centralized website that lists each Park's resources for ATBI efforts and provides summaries of past events. While not all of the parks are always conducting ATBI activities due to lack of funding, staff, or cooperating researchers, their interest and organization promise future success. Dr. Cobb also has become the lead researcher for George Washington Birthplace National Monument, a small cultural park 2,000 miles away. Resource managers recognized the necessity of inventorying species on this small parcel of land, as well as the potential to complete a full list of species occurring on this "island" of preserved space. To accomplish their goals, George Washington holds BioBlitzes in which members of the general public help to collect invertebrates, which entomologists at Northern Arizona University identify.	Acadia National Park has hosted nine BioBlitzes since 2003, with a specific taxonomic focus each year: ants, beetles, butterflies, and more. As a result of these efforts, they have identified 1,077 species in the park. Because Acadia has a rich legacy of insect, spider, and other invertebrate collection by William Proctor, their goals to collect information for management are well-met through regular BioBlitzes rather than an ATBI. Park managers are proud of the level of public involvement in the BioBlitzes: "They're not all professionals, the people who come; there are a lot of amateur entomologists," said the park's chief of resource management. Over the years, those amateurs have formed a dedicated group of knowledgeable biodiversity supporters. According to the park, 80–90 percent of participants return year after year. The Potomac Gorge, which includes the C&O Canal and George Washington Memorial Parkway, conducted a 30-hour BioBlitz with The Nature Conservancy in 2006. They had lofty goals: to survey algae, slime molds, fungi, bryophytes (such as orchids), select flowering plants, spiders, insects, reptiles, and amphibians. And they did it! One hundred and twenty-four volunteer scientists, naturalists, and students joined 17 taxonomic experts on teams. By the end of the BioBlitz, they had discovered at least 1,278 species for the area. Santa Monica Mountains National Recreation Area and the National Geographic Society conducted the largest single BioBlitz yet in 2008, involving more than 6,000 volunteers, scientists, students, and NPS staff (National Geographic 2009). The BioBlitz resulted in huge numbers of specimens identified, and it got people excited, a key first step to any large endeavor. To follow up on the energy from the BioBlitz, the park is hosting inventory sessions, some of which have a place for citizen scientists or volunteers, and some that only involve a small group of subject matter experts. Santa Monica Mountains is a park that challenges the typical divisions between ATBI and BioBlitz activities. It views different events to discover species as part of a cohesive effort to add to the park's knowledge about species, no matter what each event is called. BioBlitzes in partnership with National Geographic also took place at Rock Creek Park, Indiana Dunes National Lakeshore, and Biscayne National Park.



Biodiversity Discovery can reveal the small drivers of larger ecosystems, such as the army cutworm moth that Yellowstone grizzlies depend upon. Whitney Cranshaw, Colorado State University, Bugwood.org.

Benefits of Biodiversity Discovery Across the Spectrum

As more parks undertake Biodiversity Discovery activities and present their results at national meetings, they realize a multiplicative value from their efforts. Biodiversity Discovery activities not only provide valuable information about what exists in parks, but also have multiple values aside from science, although many benefits of Biodiversity Discovery are interconnected.

Scientific Value

In the future, Biodiversity Discovery activities can play an increasingly important role in informed scientific management of park ecosystems. Biodiversity Discovery can:

- Confirm the presence of plants and animals and discover new species, particularly the lesser-known taxa such as non-vascular plant, invertebrate, and microscopic groups. The true biodiversity of national parks remains relatively unknown and exists in the tens of thousands of undocumented invertebrate and non-vascular plant species. Biodiversity Discovery is a unique, effective, and often entertaining way to document these species and discover potential future indicators of large-scale change. Most importantly, each species discovered, confirmed, and mapped can help park managers make decisions to further study and protect living resources. As such, Biodiversity Discovery is an increasingly valuable management tool.
- Reveal park biodiversity at new scales and unexplored habitats to park managers and decision makers. We may not know as much about our best-known parks as we think. At Yellowstone, Biodiversity Discovery participants discovered a species of grass new to the park. Looking below the megafauna level reorients managers to a broader perspective of biodiversity, which can lead to more comprehensive resource management and protection.
- Serve as an invaluable scientific baseline. We can see an example of this happening already at Olympic National Park, where Biodiversity Discovery efforts just began. A short-term ATBI in 2008 enlisted scientists to inventory the insects, spiders, and non-vascular plants—such as mosses and lichens—of the Elwha River ecosystem. The park faces imminent ecological change because the Elwha Dam, which has blocked the river's passage for 100 years, will be removed in 2012. Continued ATBI efforts will serve as a “before and after” study on the effects of drastic habitat change on species assemblages and adaptations.
- Reveal emerging problems in living resources and improve predictive power. In Yellowstone, biologists have long watched grizzly bears foraging on steep scree slopes for a vital protein source: the cutworm moth. Yet this moth, a migratory animal, is considered an agricultural pest in the Great Plains. Fewer of the moths are making it back to Yellowstone, and bears are not finding enough moths to support themselves. This is the type of information that Biodiversity Discovery can provide, revealing the small drivers of the larger ecosystem. In Yellowstone, the cutworm moth matters to bears and ultimately to us, because when the grizzly fails to find food in the mountains, it may head downslope many miles to forage in the trash in towns (Yellowstone Park Foundation n.d.). There are many such links and patterns that we are more likely to discover if we have organized and focused efforts such as Biodiversity Discovery.
- Answer questions on a national scale. A project to model the distribution of bee species in 75+ parks across the United States has been developed to examine the possible effects of climate variation on ecosystem services. Bees provide a critical ecosystem service, pollination, yet we know next to nothing about bees' abundances and distributions across NPS lands. We know even less about the possible effects of climate change on bee populations and the subsequent ramifications for native plant communities. Ultimately, this project will

Biodiversity Discoveries



New phylum added to park list: At the 2010 Biscayne BioBlitz, scientists discovered a phylum—tardigrades—not previously found in the park. Commonly known as water bears, these minute aquatic invertebrates reach only about 1 mm in length. Able to withstand a variety of conditions, tardigrades live in marine, freshwater, and semiaquatic terrestrial environments.



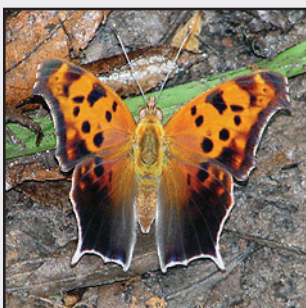
Rare species in common places: At Yosemite National Park, scientists are just beginning to explore a vast system of caves under their more well-known towering walls of granite. While they expected discoveries in less disturbed caves, a new species of pseudoscorpion (*Parobisium yosemite*) was found in a cave that thousands of people visit every year.



Most common but least studied: As part of Big Thicket National Preserve's "Thicket of Discovery" ATBI, two new species of trematodes were discovered, *Lissorchis amniculensis* and *Caecicola autumnae*, which are both fish parasites. Parasitism is probably the least understood way of life on the planet, but ironically it is also the most common, represented in about 70% of the world's taxa. Parasitic worms can teach us about host animal diversity, abundance, and food web interactions.



Some discoveries take time: After years of biodiversity activities at Great Smoky Mountains National Park, a new pattern of life emerged there. Unlike the park's plants, diversity of some of the most numerous and species-rich groups of life (insects and spiders) appears to level off or increase above mid-elevations. This means a much greater percentage of the park's natural biodiversity may be at risk to being displaced upwards and "squeezed off" mountain peaks by temperature increases than park staff originally surmised.



Park surveys contribute to national efforts: Congaree National Park has hosted annual Butterfly Counts over the last 14 years. More than 170 citizen scientists have documented almost 3,800 specimens, representing 138 Lepidoptera species. Data are entered and reported through the North American Butterfly Association national database. Consistent data from across North America are necessary to reveal climate-related trends and patterns.

Photo credits, top to bottom: Goldstein Lab, Jean Krejca, Michael Barger, Discover Life in America, NPS/Theresa Thom



A student from Northern Arizona University gains field experience working with Wildlife Technician Hank Hayou during a small mammal inventory at a 2006 BioBlitz in Canyon de Chelly National Monument. NPS/Elaine Leslie.

yield one of the largest uniformly collected sets of information about the possible effects of climate variation on any fauna. The simplicity of the sampling method will provide opportunities for citizens and staff to be involved in the science of climate change, increasing their awareness and understanding of the issue and highlighting the very substantial role protected areas can play as ecological laboratories in the study of climate change. Such coordinated studies leverage the geographic scope of the National Park System to answer ecological questions of national interest.

- Provide incentive for scientists, volunteers, and supporters to help in the search for biodiversity. Biodiversity Discovery activities that involve the public—volunteers, non-NPS scientists, or other NPS staff—suit many parks’ needs for baseline data about the species that exist in their park. With most of these activities, many hands and minds come together to ponder, explore, and collect an incredible amount of information in a short time. During the Biscayne BioBlitz in 2010, more than 2,500 people—including 200 scientists and 1,300 registered school children—identified more than 800 species and added a new phylum (Tardigrades) to the park’s species list. The human-power in volunteer Biodiversity Discovery activities can be enough to accomplish surveys and collections in just a few days that would not be possible using existing funds or relying on park staff, or with researchers working alone over many years.

- Help park scientists present science information to management, the community, and politicians. Often, a Biodiversity Discovery event is the catalyst for reporting results to managers, the media, and the public. Without these specific events, it is sometimes difficult to call attention to scientific findings or research, because there are often several (and sometimes dozens) of ongoing research projects. Too often, visiting scientists may conduct fascinating research in a park but deliver the results only in a printed dissertation or tables to be filed. The excitement of their

discovery—and the importance of their findings—may not ever reach park management, and most certainly will not reach the public. Biodiversity Discovery events create an occasion to look for life and to celebrate the findings with other participants. This forum for presenting science is especially important for the rarely studied, but often ecologically important, taxonomic groups that Biodiversity Discovery targets.

- Generate new research questions based on discoveries of species and their condition in parks cooperatively with their academic and non-profit partners. Biodiversity Discovery can clarify research questions, guiding interest and funds to species that can indicate change. In the Great Smoky Mountains, for example, an ATBI project to explore diversity of high-elevation springs and streams found not only high numbers of the diatom species *Eumotia subarcuatoides* but also many deformities in their cell structure. This led to further research to investigate ecological conditions of springs that were previously presumed to be pristine.

In addition, events at national parks can spark interest in neighboring protected areas, such as state parks and forests, city parks, and nature preserves. This has happened at Great Smoky Mountains: Tennessee State Parks are engaged in their own Biodiversity Discovery activities, many based on the Smokies’ models. South Carolina State Parks are also conducting Biodiversity Discovery activities. These regional collaborations add to a landscape-scale understanding of species diversity and distribution and can also prompt research questions across scales that have not been addressed before.

Social Value and Park Relevance

Equally obvious, but less studied, are the benefits that Biodiversity Discovery has to society and to parks themselves. During Biodiversity Discovery events, individuals form lasting bonds with the park—the land itself and the people who manage it, creating enduring relationships that are more dif-

Involving people in discovery is one of the best ways to add supporters of the National Park Service...because it allows people to indulge their sense of wonder and, ultimately, fall in love with the land. When people care about their parks, they act to protect them.



difficult to quantify, but that are unquestionably powerful and deeply meaningful. The social benefits include what students and scientists share as they sit together on the forest floor and sift through leaf litter. Here students smell the rich tang of fall leaves and soil in the sun. They hear the scientists naming, in Latin, the millipedes and beetles they've just found, the hush of far-off wind, and an occasional exclamation of "Cool! Look at this!" These qualitative experiences are tied to sound science and also to forming an appreciation of place and a sense of personal relevance in a larger process of resource protection.

Aldo Leopold worried in 1949 that "our educational and economic system is headed away from, rather than toward, an intense consciousness of land. It is inconceivable to me that an ethical relation to land can exist without love, respect, and admiration for land, and high regard for its value. . . . something far broader than mere economic value" (1989). Richard Louv, in *Last Child in the Woods* (2006), noted that in many ways we have lost this relation. "Our society is teaching young people to avoid direct experience in nature," he wrote, and as a result, they often do not form an "intimate, familial attachment to the land and water" as previous generations did. Biodiversity Discovery activities are one way to provide a direct experience in nature. In particular, they invite a whole new generation back to

wildlands and, in line with the Department of the Interior's Youth in Natural Resources Initiative, may inspire youth to pursue new outdoor careers.

Bringing volunteers together to conduct biological surveys excites people about the living things around them and creates a ready team of experts allied for resource preservation.

Biodiversity Discovery also has tangible and significant outreach benefits to the parks in which these events occur, including:

- Raising awareness of park natural resources amongst the public and within the parks themselves, especially for often overlooked but important and fascinating species groups, such as insects, fungi, spiders, and microbes. Many parks, especially in urban areas, are surrounded by communities of people with little knowledge of or access to the amazing biodiversity that literally exists on their doorsteps. Biodiversity Discovery provides unprecedented hands-on opportunities to experience this biodiversity with expert scientists, building appreciation and constituencies for scientific studies in parks.

Biodiversity Discovery is also an opportunity to excite national park staff without direct access to the field, or with cultural resource backgrounds, about the diversity



Biodiversity Discovery events, such as this 2009 BioBlitz at Acadia National Park, bring people of all ages together to explore science in parks. NPS/David Manski.

“We’ve garnered a whole cadre of supporters of the National Park System. This is an indirect benefit—these people have an intimate experience with Acadia. They understand the park’s purpose and why they’re here—I could email them and garner public support on any issue to support the park’s mission.”

—Acadia National Park manager

of life outside their windows. In many parks, education and law enforcement rangers, maintenance staff, and administrative employees play active roles in planning and conducting Biodiversity Discovery activities. Sometimes they also take part in collections and interact with the public in a refreshingly positive, often re-energizing way. This allows them to see the variety of life they play a role in protecting and to feel integrated into the overall resource management, education, and protection goals that are vital to the NPS mission.

- Building lasting relationships between national parks and professional scientists or organizations, who often come to lend their expertise or seek information to further their research. These groups find more than data during their experience, in most cases. At Great Smoky Mountains National Park, Big Thicket National Preserve, and other parks, TWiGs—the Taxonomic Working Groups—come together to pool their expertise in a subject. A Biodiversity Discovery event is an opportunity for them to observe techniques, discuss problems, and generate new ideas in their field. Parks benefit greatly from the bonds formed with researchers. Following the National Geographic BioBlitz in Santa Monica Mountains National Recreation Area—an event that involved 6,000 people—organizers said they were ecstatic about the thousands of specimens that were identified, but equally valuable were the personal bonds and professional connections formed with researchers. As a BioBlitz organizer at Yellowstone said, the event was not limited by the resources or the time it takes to identify what people collect, but rather by the experts who could attend. Most parks—even those centered in urban areas with plentiful academic institutions—feel the crunch of limited taxonomists to help collect in the field and then identify the enormous number of new specimens (Nance 2009). In the future, personal bonds between parks and scientists, or between TWiG members, will generate more interest in participating and create even more successful Biodiversity Discovery events.

- Garnering life-long support from amateur scientists and park enthusiasts, who may have unique reasons for coming to Biodiversity Discovery. Some come because they already have a personal connection to the park, to the species being studied, or to the process of searching for species (such as in birdwatching or netting) (Kyle and Eccles 2009). At Acadia National Park, 80 to 90 percent of BioBlitz participants return year after year. Most are amateur or retired scientists, so they are an audience that already thinks biodiversity is “cool” and worthy of discovery. Still, the experience of working intensely on a team and discovering new life has changed their perceptions about the government as a whole, and the National Park Service in particular. One Biodiversity Discovery event planner emphasized the importance of reaching out to the public—young or old, scientist or non—because these activities teach people about the National Park Service and what we do.

The National Parks Second Century Commission (2009) recommended that the NPS “increase lifelong learning within its parks and beyond” and “enhance community conservation and local initiatives to preserve distinctive heritage resources.” Biodiversity Discovery is a key way to accomplish those goals.

- Welcoming inexperienced volunteers into their national parks and an ecosystem that is probably similar to their local home. These non-scientists may not know what to expect from Biodiversity Discovery events, but they believe in the importance of volunteering on public lands and teaching their children about science and the outdoors (Kyle and Eccles 2009).

This may have been the attraction for many at a recent event in New York City (National Park Service 2007a). At Gateway National Recreation Area, which perches on the edge of Queens, resource managers made a concerted effort to invite people who had never seen, let alone waded in, the park’s brackish bay, wetlands, or national wildlife refuge. In 2007, they



Biodiversity Discovery activities excite children of all ages about science through hands-on learning. Top: scientist with students at Santa Monica Mountains National Recreation Area BioBlitz in 2008 (National Geographic photo); bottom: child with seastar (NPS/Ray Radigan).

advertised their first BioBlitz to document animals and plants of all sorts. On the day of the BioBlitz, 12 scientists led 50 volunteers into the salt marshes and fields to search for life. The event resulted in the discovery of many living things and also excited children and parents, amateur scientists, students, and participants who never realized such rich biodiversity existed within sight of the Manhattan skyline. Organizers said that they drew interest from people who wouldn't have otherwise known what a BioBlitz was. Now people are aware, and there's a lot more interest in new events and personally being involved in Gateway life.

We know more about why people take part in Biodiversity Discovery because in addition to evaluating the science that comes from these activities, social scientists at several universities have studied participants' experiences. They find that Biodiversity Discovery can awaken a sense of wonder in park visitors and scientists alike. As Peter White, a representative of the Smokies' non-profit partner, Discover Life in America, testified to the United States Senate in 2008,

We are scientists and this is a science-based project, but the project is also a deliberate weaving together of educators and conservation managers and students of all ages. . . Our project has even inspired artists to join: photographers, painters, writers and even musicians have created works of art that illustrate and celebrate the diversity of life in the Smokies!

When people take part in science-based Biodiversity Discovery, they often carry their sense of wonder with them and express it well beyond the park's boundaries, becoming fervent advocates for exploration and preservation.

Educational Value

Because Biodiversity Discovery events often require excited minds and willing hands but not a degree in science, they appeal to children and non-scientists as much as they do

to PhDs. And because they allow a person to jump right into the exciting part of science—the wiggling or slimy or beautifully blooming part—Biodiversity Discovery events may be the ideal way to excite kids and other members of the public who are not familiar with hands-on science.

There are several reasons it is important to excite children and the general public about science.

- In the United States, our youth are falling behind in science and math compared to their global counterparts.
- In our cities and suburbs, many children grow up without having the opportunity to ramble in the woods or observe wildlife, leaving them without the direct experience of a larger world of which they are a part. Many experts worry that they will not develop an environmental ethic that can make the study of science and stewardship of natural resources more relevant.
- Many of our children have grown up viewing science as increasingly focused on fields such as microbiology and biochemistry. For many not intrinsically excited by the inner workings of DNA or cellular activity, this trend can make science less approachable and more intimidating. As a result, fewer children may grow up to become scientists, particularly taxonomists, entomologists, or other specialists who work with whole organisms. As we are realizing the critical need to know what lives in our parks, we are left with fewer experts to help us do so.
- Current complex global changes require a high level of scientific literacy that the mainstream media, which communicates in soundbites, does not always present.

The good news is that Biodiversity Discovery activities are proving a successful way to excite children—as well as their parents, teachers, and the scientists working with them. Many parks incorporate programs geared specifically toward interpretation and education into BioBlitz events, or



Interview with Dara Reyes, selected as the 2011 NPS Youth BioBlitz Ambassador, onstage at the 2010 BioBlitz at Biscayne National Park. Dara will connect youth from oceans to desert via podcasts and learning sessions at the 2011 BioBlitz at Saguaro National Park. NPS/Thomas Strom.

into school programs following an ATBI, but many benefits come simply from the discovery activity itself. The benefits to children, as well as participants from the general public of all ages, include:

- Keeping national parks relevant to a new generation through experiential learning
- Sparking an intrinsic “environmental intelligence” and allowing non-scientists to situate themselves as part of a larger ecosystem that extends beyond park boundaries
- Being introduced to lesser-known plants and animals in areas that many local participants have visited for years, thus providing a new lens through which to look at their neighborhood ecosystem
- Improving quantitative literacy, including: reinforcing the scientific method introduced in classroom science; practicing simple collection techniques, field identification, and using scientific tools such as GPS, maps, identification keys, and measurement tools; and correctly using scientific terms for equipment, sampling methods, and living organisms

- Working with expert scientists in the field and being involved in real science, thus building confidence in individuals’ abilities to form testable hypotheses and methods of field inquiry

Feedback from participants reveals that Biodiversity Discovery makes a lasting impression. BioBlitz participants at Congaree National Park said, “We can learn about these things without... [difficult] techniques—we can go out in the mountains and just see these things!” In addition to helping people to view the world through a (non-scary) scientific lens, these activities give people a chance to simply “be” in the park. “It’s nice to just sit [somewhere in the park] and experience really being hot and uncomfortable, really being cold, really being annoyed by insects,” one participant wrote and continued, “I feel more connected to nature [while in the park] which is something I lack a lot” in the city (Kyle and Eccles 2009). Experiencing unpackaged, sometimes uncomfortable nature is an experiential value that is hard to replicate, and one that unexpectedly brings people back for more.

Following the field Biodiversity Discovery events they host, many parks produce sup-

“Immersion in the natural environment . . . exposes the young directly and immediately to the very elements from which humans evolved: earth, water, air, and other living kin, large and small.”

—Richard Louv

plemental science education materials, including websites or brochures about the plants, animals, and other living things discovered to connect children and the general public to parks. Others have made their own field guides to allow park visitors to “discover” newly found species. Still others, such as Boston Harbor Islands, have made games and 3-D images of insects that rival the aliens in many kids’ video games.

Even people who have never visited these parks can benefit from the educational tools produced. At Boston Harbor Islands, every species that goes into the database also has high-resolution images that go with it. A “Bug of the Month” online page presents one common species that visitors to the park are likely to encounter. The database is useful to park managers, to university students who analyze data and have published

articles in peer-reviewed scientific journals, and to K–12 students who, in the future, will be able to extract data from the database and manipulate it, map species locations, create charts and graphs, and pull out pictures.

All of these efforts have intangible benefits: they excite people about science and delve far beyond the “sound bite” information usually available in popular media or politics. Involving non-scientists also teaches them to care about the process of science itself, and to see it as an essential tool to monitor the world of which they are a part. Along with social benefits, these educational rewards are one more step to renewing the land ethic, the loss of which Leopold lamented, and to ensuring dedicated land stewards for generations to come.

Parks Working Together: A Future for Biodiversity Discovery in the National Park System

As we near the beginning of the second century of the National Park Service in 2016, managers, scientists, and educators at national park units are increasingly thinking about how their individual efforts can fit into a larger picture of Biodiversity Discovery and preservation. This is in line with several recent national movements that recognize the importance of biodiversity and the very real threats to our natural resources globally. These movements—and the increased public interest they will bring—have the potential to galvanize Biodiversity Discovery as a vital scientific and educational tool:

- The 2009 Copenhagen Summit on Climate Change brought new attention to this global, scientifically documented problem. The United States was implicated as the second largest contributor of greenhouse gases, after China, and also as one of many nations whose natural resources will change drastically as a result of temperature and precipitation regimes. Understanding our natural heritage will be crucial to responding to climate change impacts in the management of our parks.
- On September 14, 2009, Secretary of the Interior Ken Salazar proclaimed that in the face of climate change, the department must “provide state-of-the-art science to better understand the impacts of climate change and...develop science-based adaptive management strategies” (Salazar 2009), for which Biodiversity Discovery could provide crucial baseline inventory information.
- A new Department of the Interior Youth Initiative was announced in 2009 to encourage a new generation of scientists and environmental stewards. For the National Park Service, this will include support for internships and the Student Temporary and Student Career Employment Programs (STEP and SCEP).
- The NPS Emeritus Program proposes inviting retired science experts back into the field for park and public benefit.
- The NPS American Great Outdoors program, which has evolved from the Centennial Challenge funding initiative, will provide grants to discovery and science efforts.
- The year 2010 was declared the United Nations “Year of Biodiversity,” providing an excellent international affirmation of Biodiversity Discovery in national parks (International Union for the Conservation of Nature 2009).

Retired NPS marine biologist and science advisor Gary Davis addresses the crowd during the opening ceremony of the 2010 BioBlitz at Biscayne National Park. NPS/Thomas Strom.



Increasingly, it is vital to take individual Biodiversity Discovery efforts as part of a whole. We need to look at Biodiversity Discovery efforts not as discrete stabs in the dark, but as part of an established national effort to understand our living resources at a critical point in history.

These movements and initiatives all point to the need for parks to discover biodiversity and increasingly find new and more efficient ways to share information about biodiversity with other National Park Service managers, scientists who can apply their findings to in-depth research, and students who bear the responsibility of protecting biodiversity in the future.

An Umbrella of National Support

While budgets rise and fall annually, the resources protected within park borders—and the National Park Service itself—will thrive for years to come if we practice responsible stewardship today. Investing in Biodiversity Discovery activities at multiple scales is invaluable to the future of our parks, to ensure we comprehend fully what we are responsible for protecting.

Despite the fact that there is little federal funding earmarked for Biodiversity Discovery, and no top-down national organization, many parks are already communicating with one another and beginning ambitious (although sometimes short-term and only partially funded) Biodiversity Discovery programs. Parks face several challenges in conducting these activities, from lack of support or knowledge at many small parks, to planning events with limited budgets, to efficiently sharing data with managers and scientists. A well-planned

national effort could address these challenges while supporting the energy and incentives that come from a grassroots initiative.

Parks have begun to come together, often in collaboration with other organizations and agencies, to map out a strategy to support Biodiversity Discovery. An informal steering committee was created in 2008, and together this group has identified key actions to strengthen and build Biodiversity Discovery across the National Park System. These actions, when implemented nationally in a coordinated and collaborative fashion, will support both ongoing and new Biodiversity Discovery activities while embracing the important, park-specific grassroots approach that has been characteristic of the Biodiversity Discovery movement.

Key Components of a National Biodiversity Discovery Program

- Provide data management and curatorial support for Biodiversity Discovery, including database coordination and specimen management. With help from the NPS I&M Program, many Biodiversity Discovery events ensure that species data collected are entered into databases that link to the national NPS species database, NPSpecies. Already, NPSpecies lets parks store, manage, and share scientific informa-

A national Biodiversity Discovery program can help standardize data collection and management.
NPS/Kevin F. Noon.





Identification of specimens requires the time and expertise of taxonomists, such as the scientists at the “Thicket of Discovery” ATBI at Big Thicket National Preserve.

tion about park biodiversity (Nance 2009). However, parks could improve the linked databases by creating Biodiversity Discovery data quality standards, coupled with a set of critical common data fields to be completed for each Biodiversity Discovery event. These common data fields, in turn, would be consistent with, and easily linked to, the national NPSpecies database.

- Parks could then share information about species location and abundance, as well as their search effort and methods, with confidence that the information was reliable and comparable across a broad geographic area. These kinds of regional comparisons would demonstrate the broad reach of Biodiversity Discovery for understanding natural resource distributions on a national scale. Also, when the findings from multiple events were combined, they would help elucidate range shifts that may result from environmental changes such as climate change.

Biodiversity Discovery events often generate many specimen collections. Tools for sharing experiences and streamlining collections management would be extremely helpful. Repository agreement templates designed for specific types of Biodiversity Discovery activities could be an important first step and something that a national program could reasonably initiate.

In both cases above—managing data records and the collections that result from Biodiversity Discovery events—a national program could serve as a support structure to share tools and techniques for parks that are planning events. One of the greatest challenges for any park when embarking on Biodiversity Discovery is ensuring proper and reliable data management. Consistent and easy-to-use protocols, tools, templates, and database structures would go a long way toward alleviating this up-front challenge.

- Offer access to taxonomic expertise, sampling protocols, and other technical support. One result of a reduced focus on taxonomy in academic programs is that

there are fewer experts able to identify specialized groups of organisms. Mention millipede taxonomists amongst a group of NPS managers from parks across the country, and only one name comes up as the “go-to-guy” for expert identification. But this expert cannot volunteer all of his time to travel between Maine, Texas, and Alaska to identify millipedes for free. The result is that parks compete for his—and other experts’—attention, which does not benefit the National Park Service or scientific understanding overall.

National organization would facilitate parks’ access to taxonomic expertise for Biodiversity Discovery events. As a result, individual parks could plan and conduct their activities more efficiently, and parks would be aware of the best taxonomic experts for their projects. Increased coordination also may allow parks to organize some nationwide Biodiversity Discovery events, which could attract taxonomists, volunteers, and funders interested in taking part in a large-scale project. Because people who participate in one event are often interested in other similar events, this kind of participation might set a ball rolling to enable more events at small and large scales across the country.

Finally, parks often face the challenge of adequately compensating taxonomists: Biodiversity Discovery events can generate hundreds or even thousands of specimens, the identification of which requires a microscope and many hours per organism. Through taxonomic fellowships or a proposed “Taxonomist-in-Parks” program (like the existing Geologist-in-Parks program), parks could enjoy the services of recently graduated taxonomists or students, and the young scientists, in turn, could gain invaluable experience for their specialized careers.

- Provide a clearinghouse for sampling designs, logistical tools, and inter-program collaboration for parks conducting Biodiversity Discovery activities. As more parks embark on Biodiversity Discovery events, the opportunity for and importance of col-



Park ranger programs, such as this program at Santa Monica Mountains National Recreation Area, can be an important part of Biodiversity Discovery events. National Geographic photo.

laboration are magnified. Parks learn new lessons each time, as well as new ways to improve programs or coordinate sampling efforts. Already, parks are collaborating with I&M networks, Research Learning Centers, Cooperative Ecosystem Studies Units, and the Encyclopedia of Life, as well as with other parks that have extensive experience conducting Biodiversity Discovery efforts across the country. By working together we can ultimately magnify the returns of any individual park's sampling and outreach efforts. A national effort could catalyze further efforts to work together, sharing experiences and increasing the efficiency and value of Biodiversity Discovery events. A clearinghouse could similarly provide information on taxon-specific sampling protocols, research and collecting permit templates geared toward event types, and other logistical tools (Nance 2009).

To begin this effort, the NPS Biological Resources Management Division in Fort Collins, Colorado, in collaboration with the Biodiversity Discovery steering committee, is drafting a Biodiversity Discovery handbook and other planning resources that point to key steps in conducting events. As

seen in the discoveries and descriptions above, there is no "typical" Biodiversity Discovery activity, largely because there is no typical park in the National Park System. What works for a huge desert park may not work well for an urban cultural park. Still, people planning Biodiversity Discovery activities can learn and adapt from others' experiences. The handbook outlines some of these considerations for finding the right Biodiversity Discovery activity, including:

- Park science and management goals
- In-park resources and support, including staff numbers, funding, and encouragement
- Outside collaboration and support, including experts willing to help, organizations willing to fund projects, and information sharing between park units
- Previous activities in the park, or in cooperation with other parks
- Present a consistent purpose and sense of continuity between parks in conduct-

It is necessary that all parks, regardless of their size, focus, or level of prestige, have opportunities to conduct Biodiversity Discovery activities, and that they benefit from the wealth of knowledge gained through a decade of Biodiversity Discovery in parks across the country.

ing Biodiversity Discovery. For the public attending one of these events, the park represents the entire National Park Service. Each unit represents the ideals and mission of the whole, so each park unit—no matter its size, emphasis, or past history of discovering biodiversity—should be tapping into larger, ongoing ideas about the importance of these activities to science and society, as well as seeking more practical guidance on conducting such activities. Each park does not have to do the same activities—far from it. Rather, the attributes, resources, and special purpose of each park may indicate a need for different approaches or intensities of ATBI and/or BioBlitz efforts (National Park Service Biodiversity Steering Committee 2010). As the National Park Service assumes a national role in discovering biodiversity through a unique model, it needs to offer ideas about Biodiversity Discovery activities that will fit the needs and constraints of an individual park and help it fulfill shared goals of increased science knowledge and public engagement.

Linking to ongoing, umbrella Biodiversity Discovery knowledge and resources can also help managers and educators gain support at small or cultural parks that are not always seen as valuable biodiversity reserves. Well-organized efforts to discover biodiversity across the National Park Service would reveal patterns in species distribution across geographic areas, and provide the “state-of-the-art” science information that Secretary of the Interior Ken Salazar declared vital to address climate change challenges. Discovering biodiversity nationwide is important because national parks themselves represent the diversity of life in the United States as a whole.

The manager of a small cultural park reported that through national communication with other parks that have conducted Biodiversity Discovery activities, superintendents are able to see what is happening at other small parks and to learn that such events are possible—and beneficial—at their own parks. Increasingly, it is clear that a park’s acreage or founding purpose do not

make the life within it any less intriguing, or mean that it is less critical in understanding global changes in biodiversity. It is necessary that all parks, regardless of their size, focus, or level of prestige, have opportunities to conduct Biodiversity Discovery activities, and that they benefit from the wealth of knowledge gained through a decade of Biodiversity Discovery efforts in parks across the country.

Through the work of its Biodiversity Discovery steering committee, the National Park Service has started to build a national umbrella of resources to support Biodiversity Discovery, including sharing experts and data and having a pool of effective, sound, science-based Biodiversity Discovery activity examples. Although not all parks presently conduct Biodiversity Discovery activities, it is clear that these activities yield tremendous scientific, social, and educational benefits, as well as information invaluable to future management.

As we attempt to understand biodiversity and its health during large-scale changes, we need a way for more interested parks to join the effort. National organization would provide multiplicative benefits for parks through collaboration. To preserve the wealth of biodiversity in our national parks in the face of daunting threats for the future, we need to dedicate time, resources, and commitment to making Biodiversity Discovery possible on a much larger scale.

In the first century of the National Park Service, we made a national decision to protect unique landscapes from development. People come to these lands for enjoyment and inspiration and, increasingly, for scientific investigation. As we move into the second century and beyond, we must look to the biodiversity on our lands as invaluable. It is the key to understanding and acting upon disturbances such as climate change, and is the ultimate inspiration for future stewards. Biodiversity Discovery emerges as the ideal tool to accomplish these goals and ensure that future management is born of both sound science and public passion.



Trapping moths at Santa Monica Mountains National Recreation Area's 2008 BioBlitz. National Geographic Society photo.

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Appendix A. Timeline of Key Biodiversity Activities in the National Park Service

Year	Biodiversity Discovery Event
1997	First Discover Life in America (DLIA, Great Smoky Mountains' non-profit partner) conference is held
1998	First ATBI formally begins at Great Smoky Mountains National Park, with Discover Life in America
2000	DLIA signs General Agreement with the National Park Service
2001	Idea of ATBI expands to six parks ATBI Alliance begins
2002	North Cascades National Park begins vascular plant forays with public volunteers and botanists Tomales Bay Biodiversity Inventory begins BioQuests at Point Reyes National Seashore
2003	Acadia National Park holds its first invertebrate BioBlitz NSF Planetary Biodiversity Inventory worldwide grant funds inventories for Eumycetozoans (slime molds) in three dozen NPS units over several years
2004	ATBI Alliance becomes subgroup of Discover Life in America North Cascades extends vascular plant forays to parks within network: forays begin at Ebey's Landing National Historical Reserve (NPS, TNC, and WA state park owned) and Mount Rainier National Park
2005	Boston Harbor Islands National Recreation Area launches first BioBlitz with Harvard University, coordinated by E.O. Wilson Canyon de Chelly National Monument begins arthropod inventory, involving teams of scientists, college students, and general public volunteers
2006	ATBI Alliance data workshop is held at Smokies with funding support from National Biological Information Infrastructure DLIA develops subgroup to work on ATBI Alliance Congaree National Park conducts first BioBlitz on spiders National program of ATBIs across National Park Service is proposed as "Creating Environmental Stewardship" project Potomac Gorge BioBlitz with The Nature Conservancy surveys life at two urban corridor parks The Colorado Plateau ATBI begins collaborative five-year strategic plan with 16 of 36 regional parks and seven cooperating universities
2007	First annual BioBlitz in partnership with National Geographic Society is held at Rock Creek Park in Washington, DC Big Thicket National Preserve and non-profit partner Thicket of Diversity hold first BioBlitz Yellowstone National Park begins Aquatic Molecular ATBI
2008	Centennial Challenge (in 2009, name changed to "Treasured Landscapes") funds ATBI efforts in nine parks May 30–31, second annual BioBlitz in partnership with National Geographic Society at Santa Monica Mountains National Recreation Area, near Los Angeles, California, documents more than 1,700 species with 6,000 participants National meeting of parks interested in Biodiversity Discovery is hosted in Fort Collins, Colorado Rocky Mountain National Park begins Mycoblitz effort to inventory fungi in park
2009	Handbook is drafted for parks planning their Biodiversity Discovery activities Third annual BioBlitz in partnership with National Geographic Society is held at Indiana Dunes National Lakeshore Yellowstone National Park holds its first BioBlitz All Taxa Biodiversity Discovery User Needs Assessment report is published, based on interviews with parks about collaborative databases National Park Service participates in panel at 13th annual DLIA conference
2010	Fourth annual BioBlitz in partnership with National Geographic Society is held at Biscayne National Park Santa Monica Mountains holds Science Day Congaree National Park holds Moth Blitz

Appendix B. Glossary of Terms

National parks undertake many different Biodiversity Discovery efforts with the shared goal of pooling expert knowledge to organize collections and identification, bringing citizen scientists into the field, educating the public, and better understanding the diversity of life in our national parks. Here are some important terms used in discussions of Biodiversity Discovery:

ATBI - All Taxa Biodiversity Inventory is an intense inventory of all taxa (groups) to the species level within a geographic area, followed with further inventory as needed by specific taxa and in-depth basic and applied biodiversity research and development (Janzen and Hallwachs 1994). ATBIs are often long-term, park-wide efforts.

BioBlitz - A short-term (usually 24- to 48-hour), highly publicized field collection and identification event, often involving the public and experts in the field. BioBlitzes often have either a taxonomic focus (collecting beetles, or butterflies, or fungi, for example) or an ecosystem focus, such as a search for all the types of plants and animals in a park's wetlands (based on Karns et al. 2006; Lundmark 2003). Some parks conduct BioBlitzes to supplement ATBI collections, while others conduct BioBlitzes but do not claim to be undertaking a larger ATBI.

Biodiversity - The variety of living organisms considered at all levels of organization, including the genetic, species, and higher taxonomic levels, and the variety of habitats and ecosystems, as well as the processes occurring therein (Meffe and Carroll 1997).

Citizen science - Citizen science refers to participation of the general public as field assistants in scientific studies (Cohn 2008; Irwin 1995). Volunteers (citizen scientists) may have little to no specific scientific training, or they may be retired professional scientists. They typically perform or manage tasks such as observation, measurement, or computation.

NPSpecies - A national database into which parks can enter species records, and which is accessible by the public and other parks.

Appendix C. National Park Service Biodiversity Discovery Events (Planned and Conducted)

Code	Park	Effort name	Dates	Estimated participants	# species discovered
ACAD	Acadia National Park	BioBlitzes	2003–present	230	1,200+
ARCH	Arches National Park	Colorado Plateau ATBI	n/a	n/a	n/a
AZRU	Aztec Ruins National Monument	Colorado Plateau ATBI	n/a	n/a	n/a
BAND	Bandelier National Monument	Colorado Plateau ATBI	n/a	n/a	n/a
BISC	Biscayne National Park	BioBlitz	2010	2,500+	800+
BITH	Big Thicket National Preserve	ATBI, BioBlitzes	2006–present	2,384	800+
BOHA	Boston Harbor Islands National Recreation Area	Invertebrate ATBI, BioBlitzes	2006–2010 (ATBI), 2005–ongoing (BioBlitzes)	234	1,350
BRCA	Bryce Canyon National Park	Colorado Plateau ATBI	n/a	n/a	n/a
CACH	Canyon de Chelly National Monument	Arthropod Inventory, ATBI	2005–2007	20	5,000 (specimens)
CANY	Canyonlands National Park	Colorado Plateau ATBI	n/a	n/a	n/a
CARE	Capitol Reef National Park	Colorado Plateau ATBI	n/a	n/a	n/a
CHIS	Channel Islands National Park	ATBI	future	n/a	n/a
CHOH	Chesapeake and Ohio (C & O) Canal NHP	Potomac Gorge BioBlitz	2006	141	1,278
CONG	Congaree National Park	BioBlitzes & Inventories	2006–present	175+	700–800
DEVA	Death Valley National Park	Invertebrate BioBlitzes	2007–2008	n/a	200
EBLA	Ebey's Landing National Historic Reserve	Vascular Plant Forays	2004	10	221
ELMA	El Malpais National Monument	Colorado Plateau ATBI	n/a	n/a	n/a
ELMO	El Morro National Monument	Colorado Plateau ATBI	n/a	n/a	n/a
FOBU	Fossil Butte National Monument	Colorado Plateau ATBI	n/a	n/a	n/a
GATE	Gateway National Recreation Area	BioBlitz	2007, 2009, 2010	210+	1,100
GEWA	George Washington Birthplace NM	BioBlitzes	2008–present	45	860
GLAC	Glacier National Park	Individual taxa inventories	ongoing	50	200
GLCA	Glen Canyon NRA	Surveys	n/a	n/a	n/a

Code	Park	Effort name	Dates	Estimated participants	# species discovered
n/a	Grand Staircase Escalante National Monument	BioBlitz	2009	n/a	n/a
GRBA	Great Basin National Park	BioBlitzes	2009, 2010	66	47
GRCA	Grand Canyon National Park	BioBlitzes, Inventories	1999–2004 (BioBlitz), ongoing inventories	n/a	n/a
GRSM	Great Smoky Mountains National Park	ATBI (including BioBlitzes, etc)	1998–present	800+	6,582
GWMP	George Washington Memorial Parkway	Potomac Gorge BioBlitz	2006	see CHOH	see CHOH
n/a	Hovenweep National Monument	Colorado Plateau ATBI	n/a	n/a	n/a
INDU	Indiana Dunes National Lakeshore	BioBlitz	2009	5,929	1,200
JOTR	Joshua Tree National Park	BioBlitz, inventories	2010 (BioBlitz), ongoing inventories	300	1,646
MACA	Mammoth Cave National Park	ATBI	n/a	n/a	n/a
MEVE	Mesa Verde	Invertebrate Inventories	1999–2007	n/a	741 (and counting)
MORA	Mount Rainier National Park	Plant forays	2004–2007	20	518
NABR	Natural Bridge National Monument	Colorado Plateau ATBI	n/a	n/a	n/a
NOCA	North Cascades National Park	Plant forays	2002–present	37	1,757
OLYM	Olympic National Park	ATBI	2008	n/a	813
PARA	Grand Canyon-Parashant NM	ATBI	n/a	n/a	n/a
PORE	Point Reyes National Seashore	Forays, inventories, bioquests	2002–present	680	4316
ROCR	Rock Creek Park	BioBlitz	2007	200	661
ROMO	Rocky Mountain National Park	BioBlitzes	2008–2009	523	240
SAMO	Santa Monica Mountains NRA	BioBlitz	2008	6,000	281
SEKI	Sequoia-Kings Canyon National Park	Inventory	n/a	n/a	30
YELL	Yellowstone National Park	ATBI, BioBlitz	2007–2009 (ATBI), 2009 (BioBlitz)	125	1,079
YOSE	Yosemite National Park	Inventories	2004–present	n/a	not tabulated

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