National Park Service
Department of the Interior

Appalachian Highlands Science Journal

Welcome to the third issue of the *Appalachian Highlands Science Journal*. This magazine is a compilation of articles about natural and cultural research occurring in the parks of the Appalachian Highlands Monitoring Network (Big South Fork NRRA, Blue Ridge Parkway, Great Smoky Mountains National Park, and Obed Wild and Scenic River). It is produced collaboratively by the staffs of the Appalachian Highlands Science Learning Center, the Appalachian Highlands Inventory and Monitoring Network, the Southeast Exotic Plant Management Team and the Southern Appalachian CESU (Cooperative Ecosystems Study Unit). Several of the articles in this issue focus on the exciting new finds from park inventories and research that are part of the Natural Resource Challenge, a National Park Service initiative to improve park management through greater reliance on scientific knowledge.

Susan Sachs, Education Coordinator, Appalachian Highlands Science Learning Center

In This Issue

Galax Poaching on the Blue Ridge Parkway

Galax (*Galax urceolata*). Photo credit: Gary Kauffman, USFS, National Forests in NC

Nora Murdock, Ecologist, Appalachian Highlands I&M Network; Tim Francis, Pisgah District Ranger, Blue Ridge Parkway; John Garrison, Chief Ranger, Blue Ridge Parkway

The illegal harvesting of plants for commercial sale in the herbal remedy and floral markets is of growing concern along the Blue Ridge Parkway, where individual poachers have been intercepted leaving the park with tens of thousands of plants. Numerous species of plants targeted by poachers are found in the Blue Ridge Mountains and there is evidence that illegal harvesting activity is increasing. Some of these species do not recover quickly (or at all) from intensive harvesting, and are being eliminated from habitats that are accessible to poachers. The close proximity of desirable species to the Parkway motor road makes them particularly vulnerable to illegal harvesting.

The Appalachian Highlands Inventory and Monitoring Network (APHN) is conducting long-term monitoring for several plant species known to be significant poaching targets, including galax (*Galax urceolata*). The galax populations being targeted by poachers belong to a genetically distinct form that produces very large leaves that are in demand for floral arrangements, both in the United States and abroad. This larger tetraploid form, believed by some experts to be a separate species, is limited in distribution to the southern Blue Ridge escarpment, where the Blue Ridge Parkway is located. As many as three billion galax leaves have been exported in a single year,

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Galax Poaching on the Blue Ridge Parkway

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virtually all taken from the wild in the southern Blue Ridge Mountains.

- **As of late winter 2008, APHN field crews had mapped 369 miles (79%) of the Parkway for galax, collecting data at 1,476 sites.**
- **"Poachable" populations (minimum of 50 square meters of galax; at least some leaves >3.5") have been documented at 8% (116) of the 1,476 sites surveyed. Of these, 44% (51 populations) showed visible signs of poaching in the winter of 2007/2008.**
- **Of the 116 poachable populations, 21 were very large, prime sites with many large-leaved plants. Ninety-five percent of these (20 of the 21), had been poached, many recently and repeatedly.**

In the past year, coordinates of recently poached sites were collected by I&M field crews and relayed to BLRI rangers. With assistance from law enforcement personnel from other agencies on adjacent lands, the rangers used this information to apprehend 65 galax poachers in less than three months. Over 50,000 illegally taken galax plants were seized. Harvested leaves are bought at local galax warehouses; these buyers then sell the leaves to local florists, or export them to other countries (galax brings anywhere from a penny to five cents a leaf). Park and National Forest lands have been severely impacted by these poachers, to the point where significant healthy galax populations are diminishing. Although permits to collect galax may be issued through the Forest Service during certain months, investigation has revealed that most of those contacted with a permit are in violation by either being on NPS lands or not in compliance with the conditions of the permit. Recent support of federal magistrates and U.S. Attorneys in the Western District of North Carolina has made a definite impact. Galax poachers are beginning to move north along the Parkway due to the diminishing take in highly impacted areas, high officer presence, and the severe penalties levied by the courts. Rangers are continuing investigations, as galax poaching is highly organized and continuing to increase. I&M Network staff will continue to monitor poaching impacts, and provide data to assist in protection of this vulnerable natural resource.

Park and National Forest lands have been severely impacted by these poachers, to the point where significant healthy galax populations are diminishing.

One of many bags of galax leaves recently confiscated from poachers by BLRI rangers.
Photo credit: John Anthony, BLRI

History Methodology Website Launched

Susan Sachs, Education Coordinator, Appalachian Highlands Science Learning Center

Boys attending a boarding school in Cherokee, NC in 1890.
Photo credit: Museum of the Cherokee Indian

The Appalachian Highlands Science Learning Center has developed and launched a new website that explores the methodology behind history. The project is a partnership between Big South Fork National River and Recreation Area, Great Smoky Mountains National Park, and Obed Wild and Scenic River. It was developed under one of the National Park Service's Parks as Classrooms grants. Called "Hands on History: Appalachian Cultural History Exploration," the website hosts two databases, one containing cemetery information and the other objects from each park's archives.

Curriculum units, developed by NPS archaeologists, educators, and teachers, allow students to explore each park's story by sorting through photographs of artifacts, first hand accounts, and other materials. One activity allows students to compare and contrast the educations of European-American farm children attending mountain community schools and Eastern Band of the Cherokee Indian children attending government run boarding schools. The website address is **http://www.handsontheland.org/HistoryExploration**

Appalachian Highlands Network Parks: Extraordinary Biodiversity

Nora Murdock, Ecologist, Appalachian Highlands Inventory and Monitoring Network, National Park Service

The Appalachian Highlands Inventory and Monitoring Network (APHN) includes four National Park Service units in four southeastern states: the Big South Fork National River and Recreation Area (BISO), Obed Wild and Scenic River (OBRI), Blue Ridge Parkway (BLRI), and Great Smoky Mountains National Park (GRSM). Network parks vary in size from 5,174 acres to 521,490 acres, and include two of the most-visited units in the National Park System (GRSM and BLRI).

Marbled salamander (*Ambystoma opacum*).
Photo credit: Doug Stephens

Indian pink (*Spigelia marilandica*).
Photo credit: Nora Murdock

Amphibian Diversity By Park*

Rank (out of 315 total parks)	Park	No. of Amphibian Species
1	Blue Ridge Parkway	43
2	Great Smoky Mountains National Park	41
3	Congaree National Park	33
4	New River Gorge National River	33
5	Natchez Trace Parkway	32

* Source: NPSpecies May 31, 2008
Top 5 parks for amphibian diversity in the NP system. The Blue Ridge Parkway and Great Smoky Mountains are the leading parks in the NP system for amphibian diversity; OBRI and BISO rank #12 and #13, respectively.

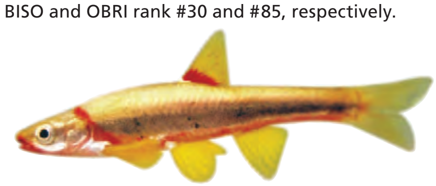
Vascular Plant Diversity By Park*

Rank (out of 315 total parks)	Park	No. of Vascular Plant Species
1	New River Gorge National River	1,888
2	Grand Canyon National Park	1,737
3	Blue Ridge Parkway	1,635
4	Great Smoky Mountains National Park	1,619
5	Sequoia & Kings Canyon National Parks	1,552

* Source: NPSpecies May 31, 2008
Top 5 parks for vascular plant diversity in the NP system. The Blue Ridge Parkway and Great Smoky Mountains are #3 and #4 in the NP system for vascular plant diversity; BISO and OBRI rank #30 and #85, respectively.

Appalachian Highlands parks are situated in one of the most species-rich temperate regions on earth. The southern Appalachian Mountains and the Cumberland Plateau are centers of diversity for vascular and nonvascular plants, freshwater fish, amphibians, freshwater mussels, snails, and neotropical migratory birds. According to the World Wildlife Fund, these two ecoregions contain the highest number of endemic species in North America. Network parks protect the largest contiguous stands of old-growth forest remaining in the eastern United States, as well as many of the best remaining examples of globally imperiled species and communities, including 409 species ranked as Critically Imperiled, Imperiled, or Vulnerable by The Nature Conservancy, and 27 species federally listed as Endangered or Threatened.

The Appalachian Mountains are among the oldest in the world, having changed relatively little over the past 200 million years. This long stability, combined with great variation in geology, landforms, and climate, has fostered enormous biological diversity, especially in the southern part of this mountain range, where the land was never covered by glaciers or inundated by oceans. This ecoregion is home to 2,250 species of vascular plants, including over 130 species of trees, and 385 terrestrial vertebrates. With 34 species of Plethodontid (lungless) salamanders, the Appalachians are the world's center of diversity for this particular group.



Blackside dace (*Phoxinus cumberlandensis*), a Federally-listed Threatened species found at BISO for the first time during Network inventories. The Blue Ridge Parkway and Big South Fork NRRA are among the top 10 most diverse freshwater parks in the NP system, with 93 and 91 fish species, respectively. Photo credit: Ed Scott

The Cumberland Plateau, extending 450 miles from southern West Virginia to northeastern Alabama, is an extensive tableland of sandstone and shale carved by water *continued on page 12*

Confronting Global Amphibian Declines in the Southern Appalachians

Matthew Chatfield, Ph.D. Candidate, University of Michigan

We are currently in the midst of an unprecedented loss of global amphibian diversity. According to the International Union for the Conservation of Nature Red List, 31% of amphibians are listed as threatened, endangered, or already extinct and 37% are declining. For nearly a quarter of all species, we just don't know their status. Causes for this decline are largely unknown, likely numerous, and acting with synergistic effects. Researchers refer to the decline of many species as merely "enigmatic." One major cause, however, has gained recent and rapid worldwide attention—infection by *Batrachochytrium dendrobatidis*, a pathogen commonly known as chytrid fungus that was likely introduced from the Old World. The details of how this species of chytrid fungus kills amphibians remain largely a mystery, but it seems to involve interference with blood solute concentrations.

Red-cheeked salamander.
Photo credit: Matthew Chatfield

No systematic search for chytrid fungus has ever been performed in Great Smoky Mountains National Park (GRSM). Of the more than 40 species of amphibians inhabiting the park, we don't even know if all are susceptible. Chytrid is known to infect certain plethodontid salamanders, the largest family of amphibians in the park. More commonly, chytrid is found in pond-breeding amphibians, usually frogs. More information on which species are susceptible and where chytrid is found is greatly needed.

With financial aid from the NPS, my colleagues—Betsie Rothermel and Chad Brooks from Austin Peay State University—and I set out to determine if chytrid is present in GRSM. During the summers of 2006 and 2007, we collected and analyzed 700 samples taken from amphibians throughout the park. Chytrid fungus infects the keratinized skin of post-metamorphic salamanders and frogs, so we were able to use the non-invasive technique of collecting fungal spores from the animals' skin using cotton swabs. Only the mouthparts of tadpoles contain keratin, so larval amphibians were collected and preserved. In the lab, we used two highly sensitive molecular techniques (known as PCR and real-time-PCR), to determine if DNA of *B. dendrobatidis* was present in each swab or specimen. Our survey revealed the presence of chytrid in a few pond-breeding species— including wood frogs and American toads—from the Cades Cove area of GRSM. None of the salamanders, however, tested positive for the fungus.

What does this mean for the park? Our findings show that chytrid is present in the park and highlight the need for preventative steps in halting the spread of the pathogen outside the Cades Cove area. Our recommendation to researchers working in aquatic habitats is to sterilize gear in a 5-10% bleach solution and allow gear to dry before entering a new water body.

Cooperative Ecosystems Study Units (CESU) Emergency Response Roster

Ray Albright, NPS Coordinator for the Southern Appalachian and the Piedmont - South Atlantic Coast Cooperative Ecosystem Studies Unit (CESU)

In the aftermath of a severe natural disaster or other major emergency at a national park, a rapid response is needed to stabilize, protect, preserve, recover, or restore natural and cultural resources and historic properties. The National Park Service response team which arrives at the affected site sometimes must turn to non-NPS experts, such as university personnel, to provide specialized skills that the NPS lacks in type or quantity. For this purpose, the NPS has been working with the 12 university partners within the Piedmont – South Atlantic Coast Cooperative Ecosystem Studies Unit (PSAC CESU; psaccesu.ugs.edu) to develop a roster of natural, cultural, and historic preservation skills and expertise to facilitate quick deployment of university experts into an impacted park.

The system requires interested faculty in each participating CESU university to take a pre-requisite of four Incident Command System on-line courses in order to register on an emergency response roster. The roster is embedded within a federal emergency database so the university expert with the needed natural, cultural or historic preservation can be easily found and contacted. The CESU cooperative agreement would be used to address issues of payment. The NPS CESU Coordinator serves as the NPS point of contact for this system. A university expert can be deployed within 24–48 hours after initial contact under this system.

An incident can be more than a major natural disaster. It can also be a terrorist attack, a wildland or urban fire, a flood, a hazardous materials spill, an aircraft accident, an earthquake, a hurricane, a tornado, or a public health and medical emergency. It helps to know that natural, cultural and historic preservation expertise within CESU universities are available for rapid deployment to assist the NPS in these critical times.

First Complex Vegetation Maps for Network Parks are Completed

Robert Emmott, Coordinator APHN; Tommy Jordan, Associate Director, University of Georgia Center for Remote Sensing and Mapping Science (CRMS); Marguerite Madden, Director, CRMS

Vegetation maps are extremely useful tools for managing park natural resources because they have so many potential applications. They are essential aids for effective fire management planning, for targeting projects related to forest insect and disease impacts, for planning plant and animal habitat studies, and for refining sampling designs for any number of research projects. Because of this obvious utility, individual parks have always looked for ways to classify and map their vegetation, but producing a detailed, high quality vegetation map for an entire park is complex and costly, and parks have rarely been able to find the resources necessary to carry out such an undertaking.

This situation changed dramatically in 2000, when funding for inventory and monitoring programs was substantially increased through the NPS Natural Resource Challenge. The new funding revitalized the NPS Vegetation Mapping Program, which set as its goal completing vegetation maps for all NPS areas with significant natural resources (approximately 270 parks) by the year 2010. The NPS Vegetation Mapping Program aims to produce high-quality vegetation maps which can be used at multiple geographic scales, and are standardized throughout the Park Service and among many other federal and state agencies. To this end, NPS is mapping vegetation according to the National Vegetation Classification System (NVC), which has been adopted as the federal standard for vegetation classification. Because the NVC is widely accepted, parks will be able to view their mapped vegetation in a larger context and more easily understand its importance for conservation at local, regional, and national scales.

The NPS Vegetation Mapping Program aims to produce high-quality vegetation maps which can be used at multiple geographic scales, and are standardized throughout the Park Service and among many other federal and state agencies.

Soon after the NPS Vegetation Mapping Program began accelerating its support for vegetation mapping projects across the country, 17 parks in the Appalachian Highlands (APHN) and Cumberland Piedmont (CUPN) Inventory and Monitoring Networks dedicated some of their discretionary funding to vegetation mapping in order to move up the national priority list for mapping. The two networks formed partnerships with the University of Georgia Center for Remote Sensing and Mapping Science (CRMS), and NatureServe, who had recently worked together to produce a vegetation map for Great Smoky Mountains National Park. Both organizations had worked well together during the Smokies project, one of the most complex vegetation mapping projects in the National Park System. During this partnership, CRMS took on the role of photo interpretation and mapping and the two organizations collaborated to classify the vegetation according to the NVC.

The Vegetation Mapping Process

For the projects undertaken by CRMS and NatureServe, vegetation mapping consists of a number of steps:

- First, color infrared aerial photos are taken, typically at 1:12,000 or 1:16,000 scale. Infrared color is used because vegetation types are much easier to identify using these wavelengths. The photos are scanned by CRMS and then the digital images are processed so that photo edges match and distortions caused by photo angle and differences in elevation are corrected.
- In order to develop meaningful vegetation classes, ecologists from CRMS, NatureServe, and NPS work together to collect historical information about the vegetation of each park, including past disturbances caused by insects, fire, ice, etc. Field investigations are

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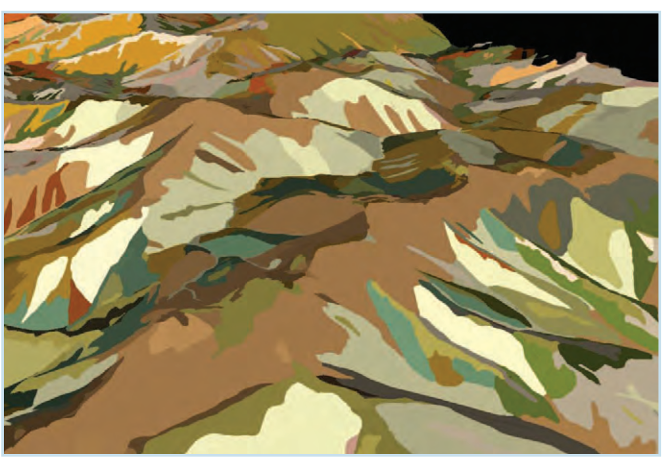
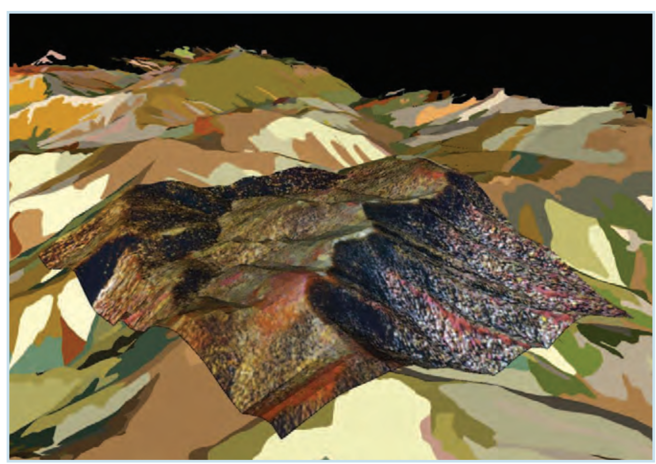


Three-dimensional view of vegetation map of Thunderhead Mountain in Great Smoky Mountains National Park.



A color infrared orthophoto of Thunderhead Mountain overlaid on the vegetation map in a three-dimensional view showing the correspondence between tone and texture on the photo and vegetation classes on the map.

First Complex Vegetation Maps for Network Parks are Completed

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conducted to collect data on vegetation types, and correlate signatures noted on aerial photographs with differences evident on the ground. At each field point, CRMS and NatureServe personnel work together to determine which NVC class (or classes) is represented. CRMS photointerpreters outline distinct vegetation types on transparent overlays superimposed on the aerial photographs, mapping patches as small as a half-hectare (a little more than an acre) in size. A stereoscope is used so that delineations will be as accurate as possible.

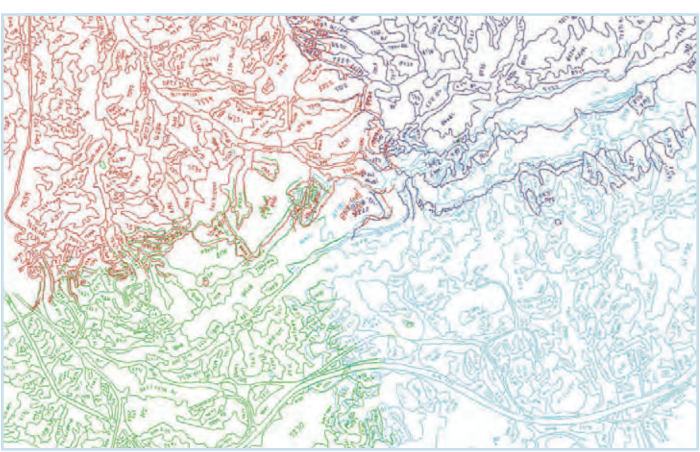
- Vegetation classes are mapped at the most detailed level—called "associations." Associations are distinguished from one another by both their overstory species composition as well as species in the sub-canopy and herb layer. Sometimes associations can be identified by photointerpreters using the overstory layer in combination with its position on the landscape (e.g. dry vegetation types along a ridge or on a south slope); in other cases supplemental "leaf off" aerial photos are used to identify understory vegetation. When information on landscape characteristics and sub-canopy vegetation isn't sufficient, then a more general class, based only on overstory vegetation, may be mapped.
- The completed mylar overlays are then scanned and corrected for elevation using the correction factors that were used when the aerial photos were first scanned. The corrected digital overlays are edge-matched, labeled and incorporated into a single seamless vegetation map corresponding to the area covered by the park.
- Finally, an accuracy assessment of the completed maps is undertaken. A series of random points is visited to determine what percentage of each mapped class was mapped correctly. Knowing the accuracy of the maps is particularly important for managers, so they can use information derived from the maps appropriately.

Results So Far

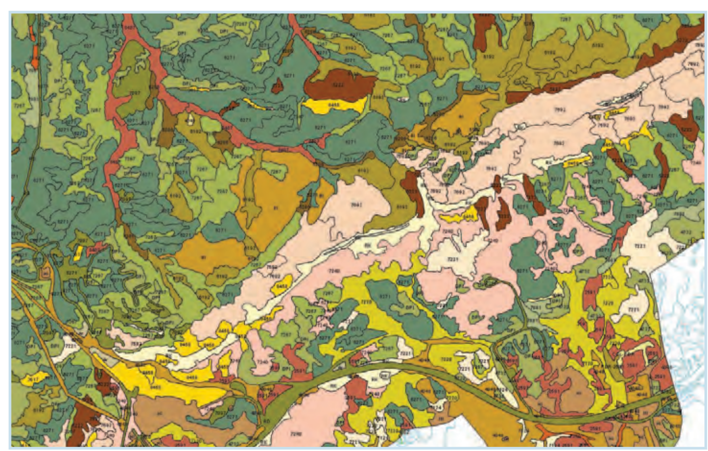
To date, draft maps have been completed for all four Appalachian Highlands Monitoring Network parks; the Smokies has finalized their map. Big South Fork, Blue Ridge Parkway, and Obed Wild and Scenic River will be working on accuracy assessments over the next two years. Looking back, the sheer size of the Smokies project was staggering. Their overstory map involved processing over 1000 aerial photographs and an equal number of mylar overlays, each of which had to be individually edge-matched and geographically corrected. Over 50,000 distinct vegetation patches were hand-drawn and identified just to complete the park's overstory vegetation map (a separate understory map was also done for the Smokies). Seven hundred man-hours were required to produce each of the 27 quadrangle-sized vegetation maps which comprise this half-million acre park.

Preliminary results of the Blue Ridge Parkway vegetation classification are impressive. For a park that was created primarily for scenic and recreational purposes, the Parkway contains one of the most diverse assemblages of ecologically significant vegetation types in the eastern United States. Seventy-five distinct plant communities (associations) were documented within the park; 24 of these are considered globally rare, and seven are considered globally imperiled. The variety of these communities ranges from seasonally inundated floodplains, to cloud forests dominated by spruce and fir, to high elevation wetlands that support boreal relict species as well as extremely rare species unique to the southern Appalachians.

Big South Fork and Obed Wild and Scenic River have already begun using their maps. Because the hemlock woolly adelgid (*Adelges tsugae*) is just reaching the Cumberland Plateau, park managers are interested in monitoring for adelgids, as well as identifying high quality hemlock stands that are candidates for long-term protection. Producing GIS maps of hemlock-dominated vegetation can be done quickly using the draft maps. With their vegetation maps, Big South Fork is delineating areas that are candidates for prescription burning and areas where fire should be excluded. For the first time, the park is able to begin constructing a scientifically-based long-term plan for using prescribed fire for ecological purposes. These are just the first of many practical applications the parks will find for their vegetation maps in years to come.



Four completed overlays that have been edge-matched and corrected to remove distortions due to elevation. The Smokies vegetation map contains more than 1,000 similar overlays.



The finished map of the same area with labeling completed.

Alluvial Bars of the Obed Wild and Scenic River Are Havens for Rare Species

W. J. Wolfe, USGS, K. C. Fitch, Tennessee Department of Environment and Conservation; D. E. Ladd, USGS

The river gorges of the Cumberland Plateau are notable for their biological diversity. The upland surface of the plateau, sandstone cliffs, forested slopes, and whitewater river channels provide diverse habitats that support a wide variety of plants and animals, including many listed as Rare, Threatened, or Endangered (RTE) by state or federal government agencies. Protecting these diverse habitats was an important justification for the establishment of the Obed Wild and Scenic River. Seasonally flooded alluvial bars—discrete deposits of river sediment—are among the richest habitats for RTE plants in the Obed River and other plateau gorges.

The Obed Wild and Scenic River offers visitors a variety of outdoor recreational activities.
Photo credit: W. J. Wolfe, U.S. Geological Survey

Alluvial bars make up only a small part of the land surface in the plateau gorges, but they support a disproportionately large number of RTE plants. For example, it was reported in 1985 that 9 of 16 (56 %) RTE plant species growing in the Obed Wild and Scenic River are found on alluvial bars. Despite the importance of alluvial bars as plant habitat, few scientific studies have focused on their geographic and physical characteristics or the role of hydrology in forming and maintaining these features in Obed and other Cumberland Plateau gorges.

> *Alluvial bars make up only a small part of the land surface in the plateau gorges, but they support a disproportionately large number of Rare, Threatened, or Endangered plants.*

In 2004, the U.S. Geological Survey (USGS) and the National Park Service (NPS) initiated a reconnaissance study of alluvial bars along the Obed WSR, in Cumberland and Morgan counties, Tennessee. The study was partly driven by concern that trapping of sand by upstream impoundments might threaten RTE plant habitat by reducing the supply of sediment to the alluvial bars. The objectives of the study were to: (1) develop a preliminary understanding of the distribution, morphology, composition, stability, and vegetation structure of alluvial bars along the Obed WSR, and (2) determine whether evidence of human alteration of sediment dynamics in the Obed WSR warrants further, more detailed examination.

What is an alluvial bar?

Alluvial bars are discrete (not continuous along the length of the channel) deposits of stream sediment (alluvium). They are commonly classified by composition, which can vary from clay to large boulders. Some alluvial bars appear, disappear, or shift position with every flood. Others were formed during extreme floods thousands of years ago and have changed little since. Alluvial bars can be rarely or frequently inundated or permanently underwater. They can be devoid of vegetation or heavily vegetated.

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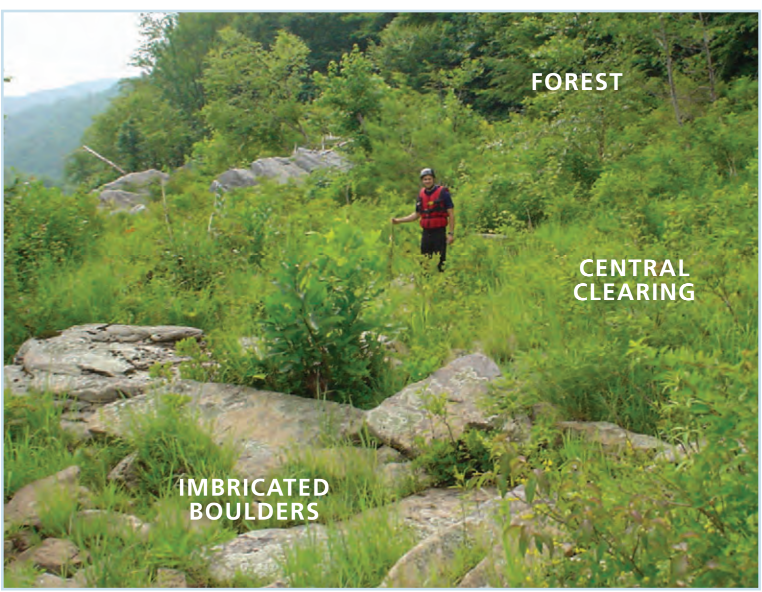

Photograph of the interior of a typical alluvial bar in the Obed Wild and Scenic River showing the central clearing, imbricated (leaning against each other with diagonal surfaces upstream) boulders, and forest vegetation near the boundary between the bar and the non-alluvial streambank.
Photo credit: W. J. Wolfe, U.S. Geological Survey

Boulders are the dominant bed material of streams in the Obed Wild and Scenic River.
Photo credit: W. J. Wolfe, U.S. Geological Survey

Alluvial Bars of the Obed Wild and Scenic River Are Havens for Rare Species

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The alluvial bars described in this article are seasonally flooded, vegetated boulder bars—composed largely of rock particles at least 10.08 inches, or 256 millimeters, in diameter (boulders). Boulders make up the structural framework of these alluvial bars and cover much of their surface area. Smaller cobbles (2.52–10.08 inches or 64–256 millimeters in diameter) are common on most of these bars. Typically, the spaces between the boulders and cobbles are filled with sandy alluvium. Surface deposits of sand and silt are common.

How do alluvial bars form?

The boulders that dominate the composition of alluvial bars in the Obed Wild and Scenic River originate in the sandstone cliffs of the gorge walls. Sandstone blocks, periodically dislodged from the cliffs, may fall or roll to the bottom of the gorge (mass movement) or they may be transported by debris flows down steep tributaries to the main channel. These processes supply enough boulders to the Obed River and other streams within Obed to provide the dominant bed material.

Boulder bars indicate hydraulic forces in the Obed River and its major tributaries sufficient to transport and deposit boulders. Determining what hydrologic conditions produce such forces and how frequently these conditions occur is problematic. The shapes and arrangement of boulders and other particles in the channel complicate the movement of coarse sediment. Rounded boulders need less energy to move than flat ones; isolated boulders are easier to move than those wedged together; boulders resting on a smooth channel bed move more readily than those on a rough bed. The relation between streamflow and boulder movement is further complicated by local variations in channel slope, water velocity, bed roughness, and similar factors.

How stable are the alluvial bars in the Obed WSR?

Evidence from published topographic maps and aerial photographs suggests that the locations and footprints of seasonally flooded alluvial bars in the Obed WSR are stable under current climatic conditions. The flood of May 27, 1973, with a peak flow for the Obed River near Lancing of about 105,000 ft^3/s and a recurrence interval of about 500 years, provides an opportunity to examine the effects of severe flooding on alluvial bars and channel geometry in general. Comparison of a pre-flood topographic map (U.S. Geological Survey, 1967) of the river channel near Nemo Bridge with a 1985 aerial photograph provided from the Tennessee Valley Authority (TVA) shows little apparent change in the location and shape of major channel features, including numerous alluvial bars. Bars near the mouths of Clear Creek and Daddys Creek show similar stability.

Stable locations and footprints do not necessarily mean that the bar surfaces are stable. On the contrary, the alluvial bars of the Obed WSR are "low energy" relative only to large rapids, cascades, hydraulic holes, and other sites of violently powerful flood flow. The surfaces of alluvial bars are high-energy settings when compared to most permanently vegetated habitats. Based on the deformation of a living maple tree on one alluvial bar, at least one large (greater than three feet) boulder was observed that had shifted position. Movement of smaller boulders across the surface of many bars may be relatively commonplace. Several of the visited bars had accumulations of large woody debris, including tree trunks with diameters of two feet or greater.

CUMBERLANDIAN COBBLE BARS

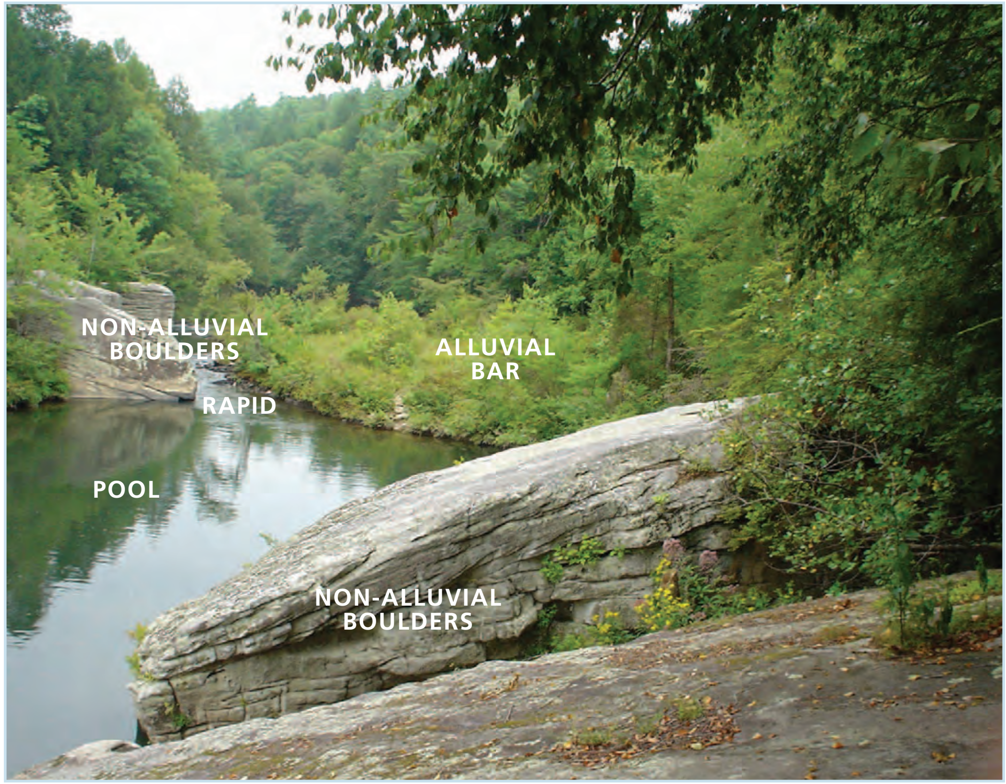
Ranked as globally imperiled by The Nature Conservancy, "river scour prairies"—a unique riparian vegetation type endemic to the Cumberland Plateau of Tennessee and Kentucky—occur on open, flood-scoured exposures of bedrock, cobble, and gravel along large rivers in the Cumberland River watershed. Also called Cumberlandian cobble bars, fewer than 500 acres (200 ha) of this habitat type remain in existence; the highest quality examples are at Big South Fork National River and Recreation Area and Obed Wild and Scenic River. These communities share many characteristics with the tallgrass prairies of the Midwest. Whereas fire is the dynamic force sustaining midwestern prairies; in the bottom of the deep river gorges of the Cumberland Plateau, the ecological driver is water rather than flame. Raging floods wash over these habitats on multiple occasions each year, scouring out species that are not adapted to disturbance, including most trees and other woody species. However, grasses, herbs, and some low shrubs thrive under these punishing conditions. Additionally, several extremely rare plants, some that grow nowhere else, flourish in these riparian prairies. Two federally listed species, Cumberland rosemary (*Conradina verticillata*) and Virginia spiraea (*Spiraea virginiana*), and several dozen other globally or regionally rare plants also grow here.

The Appalachian Highlands I&M Network is conducting long-term monitoring of the cobble bars at BISO and OBRI to determine whether these rare communities are being negatively impacted by changes in natural flood cycles or degradation of water quality. If normal flood cycles are disrupted by upstream impoundments or water withdrawal, these unique prairies and their rare and endemic species could vanish, replaced by woody plants and non-native species that, under normal conditions, could not survive there.

— Nora Murdock, Ecologist, Appalachian Highlands I&M Network

What is the ecological significance of alluvial bars in Obed Wild and Scenic River?

In the absence of floodplains, alluvial bars provide much of the available seasonally-flooded habitat. The distinctive geomorphic and hydrologic conditions of these bars have produced and maintained characteristic patterns of vegetation structure and composition. Sunny, glade-like clearings dominate the highest, driest areas of the bar. Ample sunlight, permeable substrate, elevations 3 to 5 feet above summer baseflow, and the absence of surface runoff except during floods give the bar-top clearings a distinctly xeric character, reflected in a characteristic flora of drought-resistant grasses, herbs, and low shrubs, including Cumberland rosemary (*Conradina verticillata*) and several other listed plants. Most RTE plants on alluvial bars in the Obed WSR are found in bar-top clearings. Areas along the water's edge support thickets of flood-resistant shrubs, including the RTE Virginia spiraea (*Spiraea virginiana*). Bars in contact with the valley wall typically have forest vegetation along the landward edge.



Non-alluvial boulders are too large to be moved by observed river flows. These large boulders strongly influence river morphology, including the location of the alluvial bars, rapids, and pools.
Photo credit: W. J. Wolfe, U.S. Geological Survey

What factors threaten plant communities on the alluvial bars?

Field observations do not indicate that trapping of sand by upstream impoundments is a major threat to plant habitats on alluvial bars in the Obed WSR. Surface deposits of sand and silt were found at most sites visited during this study. Because streamflow in the Obed WSR is frequently competent to transport sand and silt, the surface deposits indicate continuing supply of these materials to the channel. At sites where boulders dominated the surface, plants were observed rooted in sand or silt deposited in cracks between the boulders. The boulders at the surface act as an armor layer, protecting the interstitial sand and silt from erosive flows.

The distinctive plant communities of the bar-top clearings depend on seasonal patterns of flood and drought to resist competitive pressure from the surrounding trees and shrubs. Seasonal flooding suppresses upland forest vegetation on the bar tops through inundation and mechanical scouring. The shrub thickets at the water's edge are adapted to flooding but not to the drought conditions of the bar tops.

A major shift in the balance between flood and drought could leave the bar-top clearings vulnerable to shading by encroaching trees or shrubs. Analysis of streamflow records indicates that no reduction in the frequency or severity of flooding is presently occurring in Obed.

Urban development has the potential to adversely affect water quality in the Obed WSR. As communities in the Obed WSR watershed continue to grow, urban runoff will make up an increased proportion of streamflow in the Obed and its tributaries. Urban runoff contains elevated levels of nutrients, pesticides, herbicides, metals, and organic solvents. Any of these contaminants is a potential threat to the biota of the Obed WSR, including plants on the alluvial bars.

A more immediate threat to bar-top vegetation is the presence of non-native invasive plants. Exotics were noted on at least 8 of 56 alluvial bars visited in 2004. Five non-native species were identified. Mutiflora rose was common on at least one of the bars and represents a serious threat to shade-intolerant plants.

Video Maps of Stream Habitat Offer "Fish Eye" Views

Ray Albright, NPS Coordinator for the Southern Appalachian and the Piedmont - South Atlantic Coast Cooperative Ecosystem Studies Unit (CESU)

We are a visual culture, stimulated and enthralled by images, especially moving images. What if we could take a video journey along the bottom of a river with a "fish eye" view? That would be awesome. And what if we could use the same video to measure pools and riffles in the river? That would be discovery. It would also be applying available technology in a new way.

This is exactly what happened at the Big South Fork National River and Recreation Area (BISO) and at Great Smoky Mountains National Park (GRSM). The National Park Service utilized the Southern Appalachian Cooperative Ecosystem Studies Unit to partner with Dr. Paul Ayers, Department of Biosystems Engineering and Environmental Sciences at the University of Tennessee, to make a video run of the Big South Fork River in BISO and of Abrams Creek in GRSM. The objective was to develop a river habitat map of both sites. To do this, Dr. Ayers married a Global Positioning System (GPS) unit to an underwater video camera, then added a depth finder, laser pointers and a kayak to the mix. This allowed a GIS map of river habitat and river depth to be produced for each site.

Top: Dr. Paul Ayers mapping habitat on Abrams Creek (GRSM) using kayak equipped with underwater video camera and GPS unit in storage compartment. Photo credit: Ray Albright
Bottom: Dr. Paul Ayers and University of Tennessee student, Samba Nyika, check video and GPS equipment in kayak. Photo credit: Ray Albright

Watching the video, the viewer feels like a fish gliding down the river. While much of the video shows ordinary cobbles and boulders going by, an occasional fish scurries across the screen or a sunken log sweeps by, adding interest. Sunlight spots dance in the shallow sections while the pools look dark and sinister. The video provides a permanent record of what the stream looks like at present.

The video can also be used to measure the types of habitat (pools, riffles, runs), where they are found, and how large they are. The substrate, or channel bed rocks, can be determined as well. All this tells an aquatic biologist the abundance, diversity, and suitability of habitat in the river. Because the kayak can float the sites in a day, this saves months of traditional habitat survey work in addition to much needed funds.

In order to test the accuracy of the video, three traditional habitat surveys were conducted in three short stream segments of Abrams Creek. The traditional data was compared to the video data. They found that for habitat description, the video was right on the mark. The video did tend to underestimate the sizes of the substrate or channel bed rocks. This was because the video camera under the kayak missed large boulders which jutted up out of the water as well as large flat rocks which were wider than the kayak.

Using technology in a new way helps answer customary questions about stream habitat. In the near future, the NPS hopes to add underwater density sonar to Dr. Ayer's kayak to give a three dimensional map of river habitat, allowing us a fish eye's view of the river.

Study Traces Spread of Hemlock Woolly Adelgid in Carolina Hemlock Populations

Dr. Foster Levy, Professor, East Tennessee State University

Census transect through a population of Carolina hemlocks near Laurel Falls, Carter County, Tennessee. Photo credit: Tim McDowell

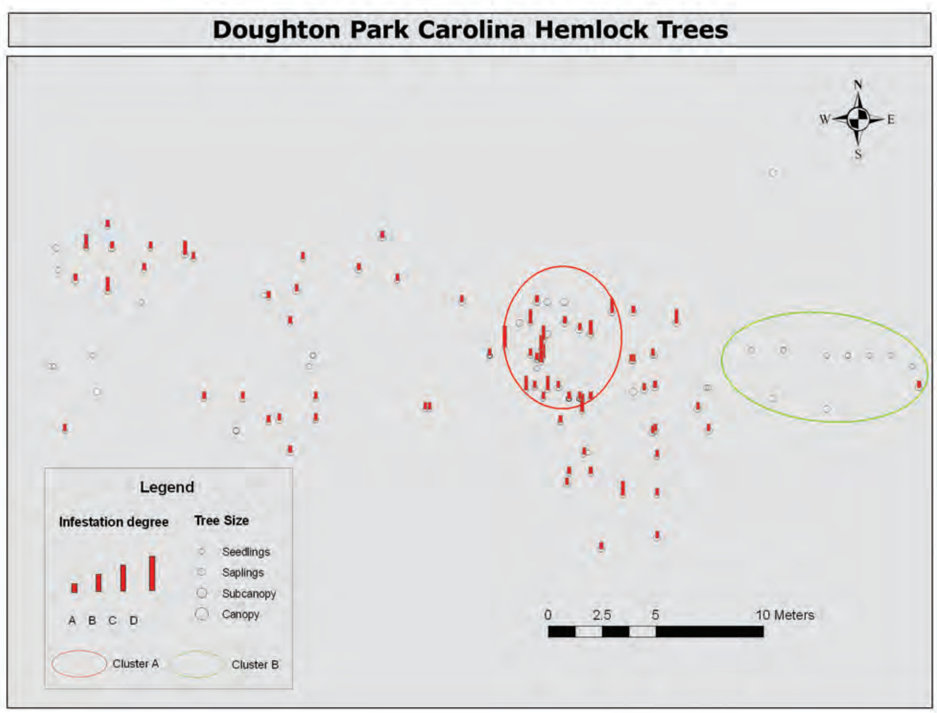
Hemlock woolly adelgid has been devastating both Canada and Carolina hemlock populations in the southern Appalachians. The insect's rate of spread and the magnitude of tree mortality constitute a disease epidemic for hemlocks. As such, it is wise to employ epidemiological principles of analysis to further our understanding of patterns by which this pathogen spreads. Our research is designed to analyze patterns of spread within populations of Carolina hemlocks after the adelgid arrives. If patterns are discernable, this knowledge may help guide chemical and biological control strategies and provide a means to assess the efficacy of containment efforts.

With financial aid, we chose four study sites, two very recently infested and two with longer histories of active infestations. One of each type was on Blue Ridge Parkway property in North Carolina—the recent infestation of a ridgeline population of Carolina hemlocks at Doughton Park and the more advanced infestation at Linville Falls. Two populations were along the Appalachian Trail corridor in northeast Tennessee—the very recent infestation near the Nolichucky River and the more advanced infestation near Dennis Cove and Laurel Falls.

In each population, we conducted a population census, mapped each individual from seedling to large tree size, and assessed degrees of infestation and tree health. The census data showed dramatic differences in tree size classes among populations. Most notably, trees in the Nolichucky River population were somewhat uniform in size with few seedlings. In contrast, all size classes were present at Linville Falls where seedlings were abundant and large trees were common.

Our first goal was to determine whether trees infested with adelgids were spatially clustered or if they were randomly distributed. Similarly, we asked whether there were clusters of trees in declining vigor. The data analysis was based on a statistical approach used to identify hotspots for human or animal diseases such as tuberculosis and rabies. In all four Carolina hemlock populations, our analysis identified adelgid infestation clusters and clusters of trees in declining vigor. During the next year, we will re-census these populations and re-analyze the data to uncover potential patterns of spread. We may observe uni- or multi-directional expansion of existing clusters, formation of new cluster foci, or merging of clusters.

A most surprising finding was at Linville Falls where many of the trees have been treated with chemical insecticide. Although there were several clusters of trees in declining health, few adelgids were present—apparently the chemical control has accomplished its job. But untreated seedlings were abundant, adelgid-free and in excellent condition, an unexpected consequence of clearing the mature trees of adelgids. If these seedlings maintain their adelgid-free status, then managers should consider *in situ* maintenance of seedling populations as a strategy to maintain genetic diversity and stocks for re-population. Even in the face of adelgid dispersal back into an area cleared of insects, seedlings can be relatively easy and inexpensive to maintain using non-toxic soap or oil applications. While the adelgid epidemic is devastating to hemlock populations and depressing for us human visitors to witness, forest managers now have the tools, knowledge, and foresight to save hemlocks from extinction.



Map of Carolina hemlocks in the Doughton Park population. Each hemlock is represented by a dot. The larger the red bar, the more highly infested the tree. A cluster of uninfested trees was identified at the eastern edge of the population (enclosed by the green circle) and a cluster of more severely infested trees is near the center of the population (red circle).

Appalachian Highlands Network Parks: Extraordinary Biodiversity

continued from page 3

into a labyrinth of rocky ridges and deep gorges. Similar to the Appalachian Mountains, the long evolutionary history of this ecoregion, coupled with a wide range of topographic and edaphic conditions, have fostered development of a rich biota and abundance of endemic species, particularly in freshwater communities. The World Wildlife Fund ranks this ecoregion's freshwater communities as the richest temperate freshwater ecosystems in the world, with globally high levels of species richness and endemism in mussels, fish, crayfish and other invertebrates.

The Cumberland River system historically contained approximately one-third of the United States' freshwater mollusk diversity. The Big South Fork and Obed Rivers are presently inhabited by 30 species of freshwater mussels, over 200 species of other aquatic invertebrates, and more than 90 fish species. This is a substantial reduction from historic species numbers, resulting from water quality degradation associated with siltation and mining. The Big South Fork has more extant federally-listed Endangered freshwater mussels and fish than any other NPS unit, and contains one of the richest and healthiest remaining mussel faunas in the Cumberland River system.

As part of the National Park Service's Inventory and Monitoring (I&M) Program, park-wide inventories of vascular plants and vertebrates have recently been completed for almost all natural resource parks, and the resulting data have been combined with the parks' legacy records to produce the first "certified" species lists for national parks in the U.S. The national database developed by the I&M Program, called NPSpecies, contains data on species reported from the parks, including observations and voucher collections, location information, reports and other references containing data about the park species, federal and state status for rare species, global ranks from The Nature Conservancy/NatureServe system, and information on whether species are native or exotic, as well as their potential for invasiveness within specific parks. Part of the job of the I&M Networks is to continue to add to and update these databases as new information is found.

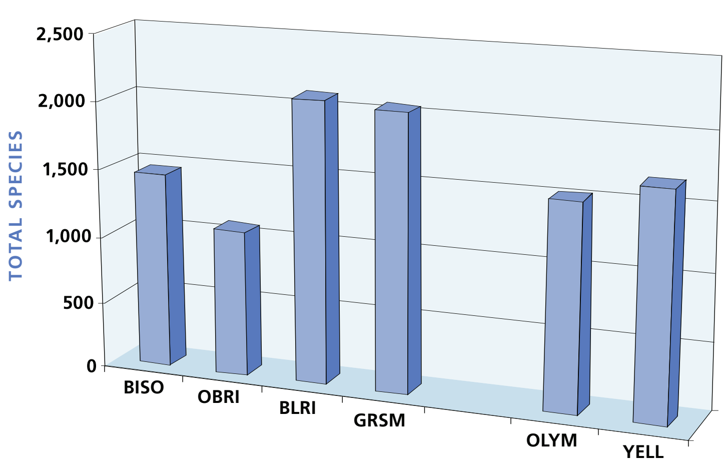
The Appalachian Highlands Network staff, to date, has documented 720 new species of plants and animals for OBRI, BISO, and BLRI, and entered 19,368 new records into NPSpecies databases for these parks. I&M staff at GRSM, a "prototype" park for the I&M Program, began this work 10 years earlier than the rest of the network, and have added many more species to that park's list. A substantial number of rare species were documented for the parks during network inventories, including first records of globally rare or state-listed species, as well as populations of federally-listed Endangered and Threatened plants and animals that were previously unknown to the parks. Unfortunately, a number of new invasive exotics were also found during network inventories.

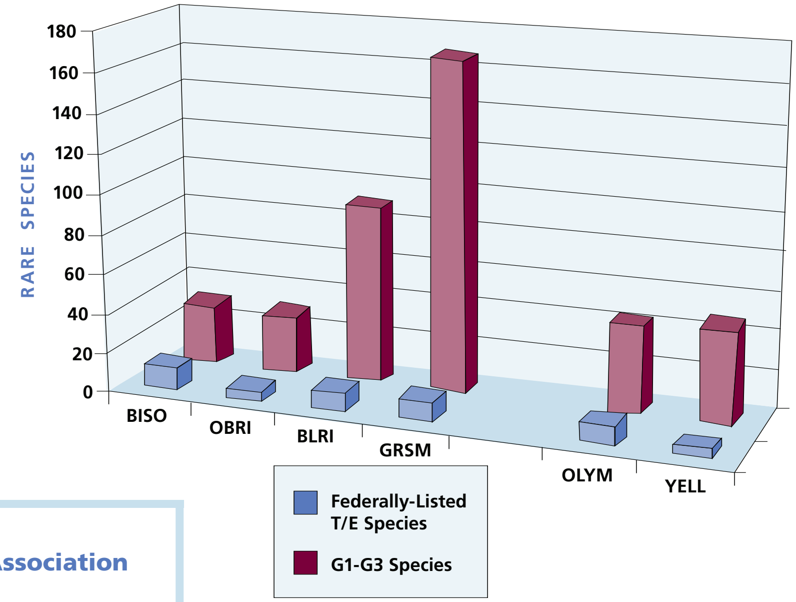
Comparison of Total Species by Park*

	BISO (125K acres)	OBRI (5K acres)	BLRI (82K acres)	GRSM (522K acres)	OLYM (923K acres)	YELL (2.2 Mil. acres)
Total Species (vertebrates & vascular plants)	1,456	1,080	2,096	2,056	1,531	1,678
Federally-listed T/E Species	12	5	9	10	9	4
Imperilled Species (G1-G3)	31	29	90	167	44	47

* Source: NPSpecies May 31, 2008

APHN parks are among the most biodiverse in the NP system and support substantial numbers of globally rare species. Comparison of total species numbers of vascular plants and vertebrates, by park. (It is interesting to compare diversity in the relatively small APHN parks with that of Olympic and Yellowstone National Parks, two much larger, "flagship" parks in the NP system.)





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