MISSOURI
Natural Areas
NEWSLETTER

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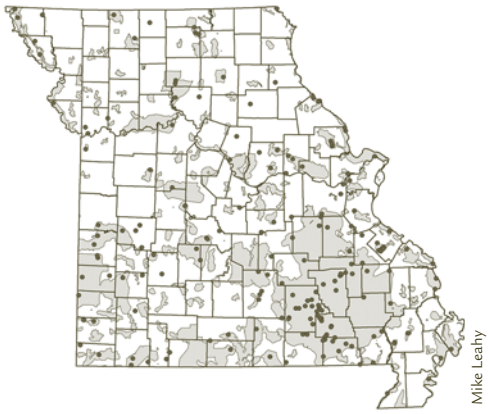
Volume 10, Number 1

"...identifying, designating, managing and restoring the best remaining examples of natural communities and geological sites encompassing the full spectrum of Missouri's natural heritage"

New Tools, Challenges, and Faces For Natural Area Conservation



Mike Leahy

Natural area managers nationwide continue to face new challenges and new realities for biodiversity and natural community conservation. Some of these, which are all too familiar for most conservation professionals, include invasive species, habitat loss, limited agency funding, water resources issues—and climate change to boot.

Concurrently, many long-time natural resource professionals are retiring and there is a need to pass their institutional knowledge on to a younger generation. Universities have been de-emphasizing organismal biology, taxonomy, and natural history studies with the result that many new professionals must learn field biology skills on the job (for more on a related topic, see the "Not Enough Botanists!" article on page 18).

The feature articles in this issue provide examples of these realities and opportunities, as well as resources and contact information for exploring these topics further. From page 18 on are natural area-related news items and a calendar of natural area related-events, including **details on the 37th Annual Natural Areas Conference, proudly held in Missouri this year!**

The Missouri Natural Areas Newsletter Committee would like to thank the authors for contributing their articles. Readers are encouraged to contact them with questions.

—Carol Davit, editor

While the content of this newsletter discusses new tools for natural area management, it is important to remember that natural areas are, themselves, "tools" for natural community and ecosystem management across broader parts of the landscape.

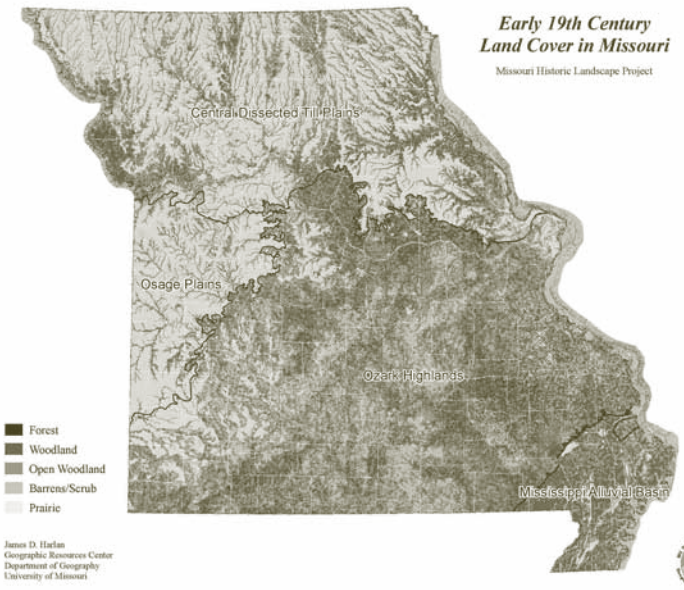
In Missouri, for example, most of the state's 180 designated Missouri Natural Areas (dots on map) are at the core of Missouri's Conservation Opportunity Areas (shaded areas on map)—landscapes determined to be the best remaining places to conserve and restore biodiversity on a viable scale to carry out Missouri's Comprehensive Wildlife Strategy. Missouri Natural Areas are reservoirs of species diversity, serving as reference points for managers and restoration biologists as they seek to improve natural landscapes to benefit both people and natural diversity.

See page 23 for conference details.

Tracing the "Ghostly Footprints" of the Landscape

Data from the Missouri Historic Landscape Project guides present-day natural community restoration efforts.

By Jim Harlan



Jim Harlan/GRC

THE OZARKS had vast areas of brushy, open landscape described as barrens or scrub, with scattered, thin timber on the plateaus and plains. Decent firewood was scarce and the land was often described in terms such as "not wurth a sent." In the more rough, dissected, steep ridges and hills along the southeast rivers and the White River basin, were the heavier woodlands of oak, hickory, and shortleaf pine. Chinquapin trees (Ozark chestnut, now nearly extinct) thrived along the White River ridges. Cedars could be found only in the rarest and more isolated locations.

The Bootheel was a place mostly of swamps, marshes, glades (e.g., Everglades), lakes, and sloughs cloaked in wet forests of sweet gum, maple, elm, water tupelo, and black gum, with a mixing of oaks. The place was full of life but miserable and dangerous to navigate in all seasons. One could step off and "sink to the antipodes" almost anywhere if not careful.

The southwestern Osage Plains sharply opened up into a panorama of rolling grassland thinly interspersed with stream bluffs of open woods of oak-hickory-elm and brushy barrens. The wider floodplains of the Osage, Marais des Cygnes, and South Grand rivers harbored large areas of grassy marshes with occasional growths of swamp oak. Still, with some exception, the land was viewed as mostly too flinty, thin, or dry for good farmer-prospect and settlement. Additionally there was also the sticky issue that the land was home of the Native American Osage and they were proud, protective, and not to be messed with.

The plains north of the Missouri River were thought to be "butiful." Thousands of square miles of rich soil comprised of glacial till and wind-deposited loess left a situation invaluable for early settlers. The land was easy to navigate. Tallgrass prairie dominated the landscape, but surprisingly strong and convenient stands of oak-elm-hickory woods were found in the more dissected hills and bluffs of the rivers and creeks. Wildlife was everywhere. Wetlands dotted the upper prairies in their concave "kettles" and in the wider floodplains, large marshes harbored ponds and lakes surrounded with cordgrass and rush interspersed with cottonwood, sycamore, hackberry, and willow. Even the buffalo and elk herds migrated here in the spring to take advantage of the early spring growth of the tallgrass prairie. The land was prime for settlement opportunities.

The Missouri River and its floodplain effectively divided the territory, north and south. It represented something to both love and fear. To love was the busy human corridor at the time offering rich alluvial soil for farming and clear access west for hunting, trapping, trade, settlement, and exploration. To fear was its unpredictable nature. It seemingly moved around at its own will. It was both docile and violent depending upon where and when. It was hard to describe, highly variable, uncertain both in water channel and surrounding land. Generally, the land cover of the bottoms altered somewhat according to the width of the valley. In the wider floodplains, prairie dominated more with strings of marshes, ponds, and lakes supplied from the incoming parallel-running tributaries and rather thin strips of cottonwood-willow along the banks. In the narrower floodplains with closer, steep limestone bluffs, there was more bottom woodland of cottonwood, hackberry, sycamore, and elm with occasional incursion of oak.

The above five paragraphs are a brief encapsulation of my interpretation or mental map of pre-EuroAmerican Missouri landscapes after shepherding a project of reading, interpreting, and mapping the early notes of French, Spanish, and American surveyors that were out trying to organize the land for settlement and ownership. This research—for the Missouri Historic Landscape Project—took more than a decade to complete to any satisfaction. However, what does this mean to us now? How should we perceive and use this?

The Missouri Historic Landscape Project yielded an encyclopedic amount of important information on the pre-EuroAmerican landscapes of the late 18th and early

19th centuries of Missouri. This offers glimpses of the land, water, and occupants long before modern urbanization and agriculture. The project culminated in the most robust and thorough historical landscape reference now available in the United States at this statewide scale. The results are historical information in the form of GIS spatial data offering general land cover, vegetative composition, settlement suitability, topography, hydrography, and early cultural features such as land grants, towns/settlements, farms, improvements, mills, mines, and roads/trails complete with names of people and dates of observation. During the project the Geographic Resources Center (GRC) scrutinized more than 100,000 pages (60 volumes) of early French/Spanish and US Government Land Office (GLO) field survey notes covering all of Missouri or more than 69,000 square miles. The total distance of survey lines we analyzed reached 140,771 miles with 133,477 in US GLO surveys and 7,294 in French/Spanish surveys. This equates to 5.67 times around the Earth.

This project, obviously, was a giant historic ecological and geographic study. These disciplines combined here to offer a corrective measure to the restoration narrative/debate where the regressives (outrage, urgency, protectionist, environmental activist) collide with the recursives (seasonally understanding, close to the land, resource using, farmer, land manager). Both sides could be seeking some environmental "base datum" for understanding and management. *Applied Historical Ecology* is the use of historical knowledge toward better management of ecosystems. *Applied Historical Geography* is the use of historical knowledge to understand the present and predict future landscapes. The *Reference Condition Approach* coupled with *Adaptive Management* may be used by all, with current assessments, social and economic considerations, and pragmatic approaches, toward achievable and sustainable goals. We have the information, so why not use it intelligently?

Jim Harlan/GRC

This computer-generated image, created by consulting historical landscape data from the Missouri Historic Landscape Project, depicts what a point along the Missouri River bottoms looked like in presettlement times. While the river and bottomland landscape have changed dramatically, the Big Manitou Bluffs shown here—along the river on the west edge of Boone County, Missouri, stretching from Rocheport to Hartsburg—remain intact today.

Recently these data have been used in various ways by private and academic researchers, federal agencies, and state agencies:

- The Mark Twain National Forest has used the information for refinement of land management programs within its numerous areas of the state while the U.S. Forest Service also used this in its national "LandFire" project.
- The U.S. Fish and Wildlife Service is implementing the information similarly in management of the Big Muddy National Wildlife Refuge areas.
- The National Park Service is using the project as a model in its resource management of the Lewis and Clark National Historic Trail.
- The Missouri Department of Conservation has used the data extensively in ecological classification work and natural area management plans.
- The Missouri Department of Natural Resources has found the work helpful in management of state parks.
- University of Missouri researchers are also implementing these data in historical, anthropological, and ecological studies; most recently in researching the implications of contemporary and historical vegetation for developing nutrient criteria for lakes and reservoirs.

> A science of land health needs, first of all, a base datum of normality, a picture of how healthy land maintains itself as a organism.
>
> —Aldo Leopold (1941)

There are some ecologists, mostly in Europe, but a few here also, who decry this approach. I understand that it is hard for Europeans, since most of that place was dramatically altered millennia past. For those more local critics who worry about using "archaic" references, I say it has only been 200 years here, not an impossible 2,000. Australians and New Zealanders realize this and are actively using their historical references. Let's look at this; understand it; inventory and note the "ghostly footprints," the existing remnants still on the land—all there to show the way if we just see it: the trajectory for ecological improvement. We have a chance, a real good chance here in Missouri.

Jim Harlan is Senior Research Specialist at the Geographic Resources Center, Department of Geography, University of Missouri–Columbia. He was the primary investigator for the Missouri Historic Landscape Project and the Lewis and Clark Historic Landscapes Project. He is co-author of *Atlas of Lewis and Clark in Missouri*. He is continuing work to reconstruct historical landscapes, culture, and ecology from old records in partnership with the National Park Service and other organizations interested in the old Missouri River geography.

Contact: James D. Harlan, 104 Stewart Hall, University of Missouri, Columbia 65211, Harlanj@missouri.edu, phone: 573-882-1356.

Additional Resource: Data from the Missouri Historic Landscape Project are available for free downloading from the Missouri Spatial Data Information Service webpage at http://msdis.missouri.edu/.

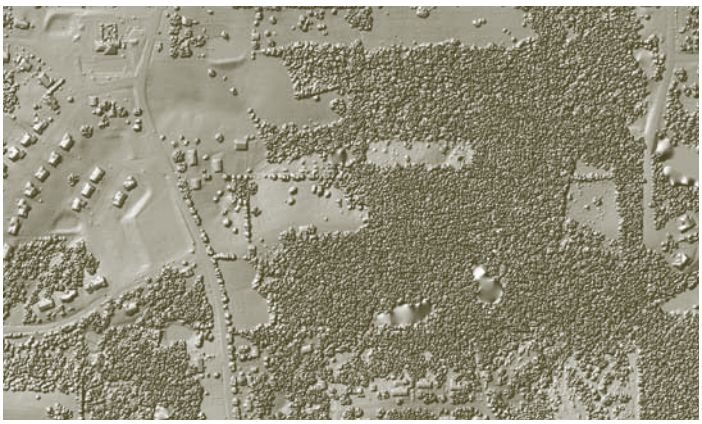
LiDAR: A Burgeoning Mapping Tool for Natural Resource Management

Light Detection and Ranging (LiDAR) is an emerging technology that offers a fast and cost-effective way to map "the lay of the land" with surprising detail and accuracy over large areas.

By Elizabeth A. Cook

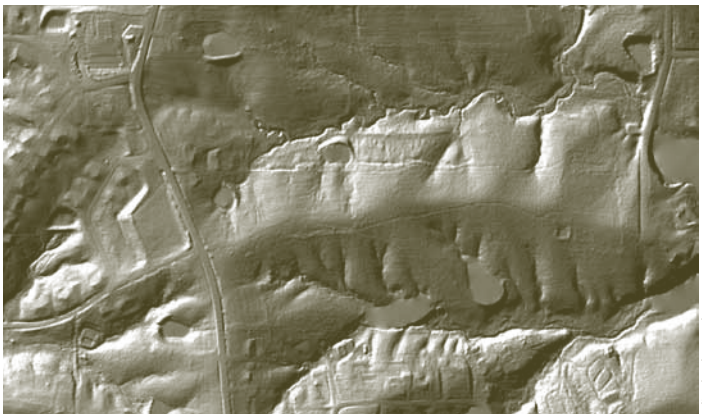
WHAT IS THE SLOPE OF AN AREA and how does that affect surface water movement and soil erosion? What solar aspect is the preferred habitat of a rare plant and where does it occur? Where are depressions on the land surface that might be sinkholes or restorable wetlands? To answer difficult questions like these, topographical information is critical for management and studies of natural resources. But often natural resource professionals have had to make do with little or no detailed terrain information. A 1939 USDA Soil Conservation Service (now the Natural Resources Conservation Service) publication stated it was "most desirable" to have a topographic map of 1 foot accuracy or less for mapping and conserving soils, which has rarely been available.

Topographic mapping over large areas has traditionally been achieved using stereoscopic pairs of aerial photographs to map spot elevations at intervals required to model landscapes to the desired accuracy, referred to as photogrammetry. Even using the latest advances in digital photogrammetry, topographic mapping of this type is labor-intensive and expensive. On-site surveying is even more time-consuming and limited by the size of area that can be covered, access to the area, and vegetation canopy. Light Detection and Ranging (LiDAR) is an emerging technology that offers a fast and cost-effective way to map "the lay of the land" with surprising detail and accuracy over large areas.



Elizabeth Cook

Figure 1



Elizabeth Cook

Figure 2

A LiDAR system is actually an integration of several technologies. It begins with a laser source that projects a beam of light at a target. An airborne LiDAR laser scanner for mapping terrain is mounted in an airplane with a hole cut in the bottom of the fuselage, along with an Inertial Measuring Unit (IMU) and a Global Positioning System (GPS). The IMU and GPS are used to accurately pinpoint the scanner location at any given moment during a flight. The LiDAR scanner emits thousands of laser pulses per second, thus creating a dense swath of laser points on the Earth's surface while flying a project area. The reflected laser pulses return to the system that calculates, based on the time of travel, known speed of light, and the aircraft position, the precise location (x,y) and relative height (z) of each reflection point. Collectively, these points may represent bare ground, buildings, or vegetation.

Current LiDAR systems are able to record up to five returns per laser pulse, giving the ability to distinguish not only the canopy (trees and buildings) and bare ground, but also surfaces in between. For example, if parts of a laser pulse reflect off tree tops, some off mid-story shrubs, and the remainder off the ground, the elevations of all can be measured. This capability is very important when trying to map ground topography beneath vegetation. The last returns for each pulse are those from the lowest features and thus are likely to be reflections from the ground. After LiDAR data are collected, automated and manual processing techniques are used to classify the data into canopy, intermediate, and bare-earth returns. The use of bare-earth only LiDAR points produces a digital terrain model (DTM) of ground elevations above mean sea level and is the most mature application of airborne LiDAR data. However, considerable work is ongoing

to exploit the information in the other returns. First return data can be used to map building footprints and vegetation height, and when coupled with intermediate returns can potentially estimate forest biomass.

Figure 1 (previous page) shows all returns of LiDAR points for an area of Warren County, Missouri, displayed as a hillshade. One can clearly see the buildings and trees. **Figure 2** (previous page) shows a bare-earth terrain model, derived from the same data after processing to remove the points that reflected off buildings and trees. The ravines present in wooded areas are accurately depicted from the returns that penetrated the tree canopy, and the developed areas are mapped as if the buildings are not there.

So how accurate are these LiDAR-derived terrain models? The accuracy of airborne terrain LiDAR data is a function of flying height, laser beam diameter, the quality of the GPS/IMU data, and post-processing procedures. Accuracies of ±15 cm (0.49 feet) vertically can be achieved. By comparison, the best available, large-area topographic mapping developed from traditional photogrammetry in Missouri has an accuracy of ±5–10 feet, depending on the mapping criteria (see comparison on Locust Creek below).

Of course, cost is still a factor when mapping topography from LiDAR data. The variables affecting cost of airborne LiDAR data include size and shape of project area, density of LiDAR points, amount of post-processing needed to meet accuracy requirements, and number of derived products requested. Economies of scale make LiDAR topographic mapping more cost-effective than traditional photogrammetry for areas exceeding about 10 square miles. Cost-sharing is a key to affordability as these data are valuable to many agencies and organizations. At present, Missouri has coverage for about 22 counties and miscellaneous small areas. The Missouri Spatial Data Information Service (http://msdis.missouri.edu) is working on making the public domain portion of these data available via the Web.

Elizabeth A. Cook is a GIS Specialist with the USDA-Natural Resources Conservation Service in Columbia, Missouri. She has spent 31 years applying geographic information systems (GIS) and remote sensing tools to natural resources management.

Contact: Elizabeth A. Cook, USDA-Natural Resources Conservation Service, Columbia, Missouri, elizabeth.cook@mo.usda.gov, phone: 573-876-9396.

Additional Resource: For more information about LiDAR-based topographic mapping, see http://lidar.cr.usgs.gov/.

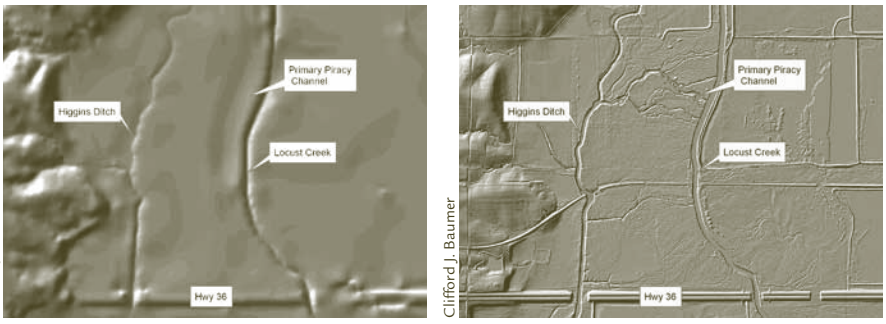
Locust Creek Stream Piracy Remediation Project Proves Value of LiDAR

By Clifford J. Baumer

The lower 19 miles of Locust Creek, from U.S. Highway 36 at Pershing State Park to the confluence with the Grand River, is one of the last remaining examples of a meandering prairie stream system in Missouri. The diverse wetland landscape that Locust Creek has created supports a wealth of plant and animal species that include the rare ostrich fern and the state-endangered eastern massasauga rattlesnake.

The long-term health of this rich landscape has been thrown into jeopardy by a process called *stream piracy*, which occurs when a stream is diverted from its own bed and flows instead down the bed of a neighboring stream. In June 2007, through events initiated more than 85 years earlier, Higgins Ditch captured Locust Creek, diverting it to the western edge of the floodplain and cutting off most of the flow through Pershing State Park.

An accurate digital model of the ground surface was essential to development of successful remediation options but heavy forest cover made conventional survey methods too costly and the existing 10m Digital Terrain Model (DTM) (left) was too coarse to be helpful. LiDAR imagery, acquired through a cost-effective state-federal partnership, provided the resolution needed to identify critical elevations and flow paths across the floodplain. Winter LiDAR collection allowed penetration of tree cover, producing exceptional "bare earth" surface definition. The LiDAR-derived surface (right) is being used to develop computer models of flow through the Locust Creek floodplain system. These flow models will guide biologists and engineers in planning remedial actions to mitigate the Higgins Ditch stream piracy.



Clifford J. Baumer

Clifford J. Baumer

Hillshades of Locust-Higgins pirated reach based on 10 m Digital Terrain Model (left), compared to 1 m LiDAR (right).

Clif Baumer is an environmental engineer with the USDA-NRCS in Columbia, Missouri. He has 24 years of engineering experience in water quality, urban stormwater management, stream restoration, and hazardous waste management.

Contact: Clifford J. Baumer, PE, Environmental Engineer, USDA, Natural Resources Conservation Service, Parkade Center Suite 250, 601 Business Loop 70W, Columbia, Missouri 65203, clif.baumer@mo.usda.gov, phone: 573-876-9418.

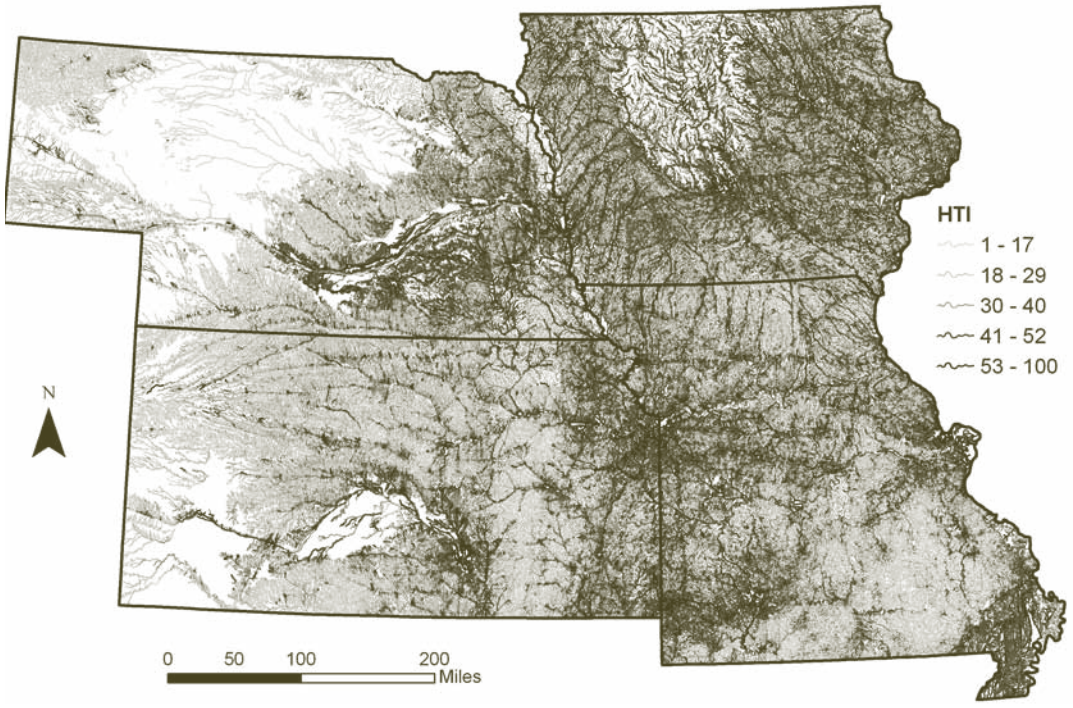
Additional Resources:
www.mostateparks.com/pershingpark.htm
www.csc.noaa.gov/products/sccoasts/html/tutlid.htm

Aquatic Human Threat Index

A New Tool for Aquatic Natural Community Protection and Management

By Gust Annis

MISSOURI'S NATURAL AREAS SYSTEM seeks to preserve the best examples of every remaining type of natural community in the state. Approximately 30 percent of Missouri's Natural Areas were designated with aquatic natural communities as their principal features. Ensuring the long-term protection of these aquatic communities requires knowledge and understanding of threats to these systems, many of which originate upstream.



OVERALL HUMAN THREAT INDEX (HTI)
Map depicting the Human Threat Index (HTI) score for each stream segment in EPA Region 7 (Iowa, Kansas, Missouri, and Nebraska). Lower values (lighter color) represent less potential cumulative threat, while larger values (darker color) represent more potential threat.

Understanding Threats Upstream

A natural community residing in any given stretch of river is impacted not only by human activities immediately adjacent to the river segment, but also by activities anywhere in the upstream drainage area. Resource managers are often familiar with local threats, but acquiring detailed information about the many potential threats upstream is more challenging. Indeed, one of the challenges that most natural resource professionals face is making good decisions based on limited information.

In order to make effective decisions, aquatic resource managers must have an understanding of the threats to aquatic ecosystem integrity. Common questions of aquatic resource managers include: what factors threaten the ecological integrity of a stream of interest, what threat is most pervasive, and where are these threats within the stream network or watershed? Answering these questions and others like them can help resource managers target specific threats at specific locations. Finally, for a decision to be objective, it must be driven by data. More specifically, many natural resource management decisions require detailed and spatially explicit (i.e., map-based) data.

Development of the Aquatic Human Threat Index (HTI)

Effective resource management requires having an accurate inventory of the resource accompanied by knowledge and information about the factors that influence those systems. The use of GIS has enhanced the ability of natural resource professionals to generate basic inventory statistics about natural resources and factors that might negatively influence these resources. With funding from an EPA Wetlands Program Development Grant and a separate 319 Grant, the Missouri Resource Assessment Partnership (MoRAP) used GIS technologies to create a threat index for each of the 1:100,000 scale stream segments in EPA Region 7 (Iowa, Kansas, Missouri, and Nebraska). The goal of the project was to quantify threats to aquatic ecological integrity in a high resolution, spatially explicit manner and provide an "index" that can be used as an initial screening tool for assessing the extent and specific causes of diminished ecological integrity of freshwater resources.

MoRAP staff working on the project, including myself, wanted to quantify potential human threats for the drainage area above each National Hydrography Dataset stream

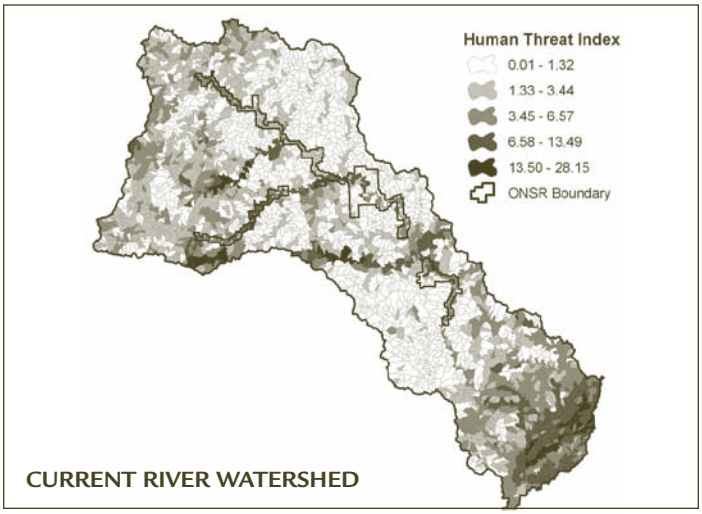
segment in EPA Region 7 and include anthropogenic land-use factors for both point and non-point source pollution using existing datasets. In addressing these objectives we sought to create a high resolution aquatic "threat assessment tool" that would be useful for on-the-ground planning and management. We wanted to utilize as many threat datasets as possible, consider the drainage area above each stream segment, and incorporate threats such as point source pollution, agricultural chemical applications, impervious surfaces, and population density among others. Finally, we wanted to incorporate these cumulative threats into an overall human threat index (HTI).

Approximately 35 geospatial data layers representing potential threats to aquatic ecological integrity were identified through the help of a regional oversight committee that was brought together to provide guidance for this project. A large thrust of the project was to collect and assemble data layers that are seamless across state boundaries. These seamless data layers allow information for watersheds that straddle state boundaries to have information accurately quantified for the drainage area above each stream segment. Once assembled and quantified, these data were used to construct an index representing potential cumulative threat from anthropogenic activities to riverine ecosystem integrity. In fact, each of the approximately 400,000 stream segments in EPA Region 7 (more than 100,000 in Missouri) received a human threat index score based on the unique types and quantities of threats acting on those stream segments individually.

Using HTI for Protection of Streams and Other Natural Communities

The resulting index and quantified threat datasets developed for this project will help answer questions such as: what threats are upstream, how much or how many threats are upstream, and where or how far are these threats upstream? The HTI will help shed light on ecological integrity and show the degree of impact any given stream reach is experiencing relative to all other stream reaches in EPA Region 7.

Although the resulting datasets developed for this project do not account for every possible threat to aquatic ecological integrity, when combined with the expertise of aquatic resource managers these data will serve as a powerful tool for developing comprehensive inventories and conducting detailed assessments for the freshwater resources within EPA Region 7. The stream reach-specific precision of these data allow inventories and assessments to move from a fixed unit state (i.e., Hydrologic Unit) to a continuum of data that provides the necessary flexibility to meet a wide range of research and management applications. Using these data, a resource manager will have at his or her fingertips information that would previously have been unavailable or taken months to acquire. We believe that the datasets developed as part of this project will provide much needed information to natural resource professionals who, in turn, will put it to use for conserving Missouri's aquatic natural communities.



Gust Annis

Understanding Threats to Aquatic Ecological Integrity in the Ozark National Scenic Riverways

The Missouri Resource Assessment Partnership (MoRAP) recently worked with the National Park Service (NPS) to conduct a condition assessment of the Ozark National Scenic Riverways (ONSR) in the Lower Ozarks of Missouri. A component of this assessment utilized a preliminary version of the aquatic Human Threat Index (HTI). The NPS was interested in determining the relative threat to each stream reach in ONSR as well as finding out which specific threats were upstream of the park, how much or how many of each type exist, and where specifically the threats were.

Most, although not all, threats to ONSR occur in the watershed outside of the park property. Although too numerous to describe in detail, potential threats to the aquatic ecological integrity of ONSR include impervious surfaces, pastures, leaking underground storage tanks, and small impoundments. The figure above highlights some of the "hotspots" of threats within the Current River Watershed where higher HTI values (darker colors) have more potential cumulative threat. Areas inside the ONSR are reflective of threats that often originate upstream outside of the park itself. As might be expected, many of these threats are associated with higher human population densities.

The spatially explicit index and accompanying data will help NPS resource managers work to maintain the ecological integrity of the ONSR's streams, enabling them to identify the specific threats to any stream segment within the park.

Gust Annis is the Aquatic Resources Coordinator for the Missouri Resource Assessment Partnership (MoRAP) at the University of Missouri. Gust has worked for MoRAP since 1998. During this time he has been involved with aquatic gap analysis and a variety of other projects related to ecological classification, the development of species models, threat assessments, and the identification of aquatic conservation opportunity areas across Missouri.

Contact: Gust Annis, Aquatic Resources Coordinator, MoRAP, School of Natural Resources, University of Missouri, 4200 New Haven Road, Columbia, MO 65201, annisg@missouri.edu, phone: 573-441-2792, www.cerc.usgs.gov/morap/.

Additional Resource: http://www.cerc.usgs.gov/morap/Projects.aspx

Hidden Worlds

Karst feature management calls for use of many tools, new and old, to protect natural communities below the surface of the land.

By Scott House

"PULL TAPE," SHOUTS THE POINT MAN. "Thirty-five point two," reads the rear tape man. "Light on for instruments," says the point man. "Bearing one forty-two," states the instrument reader, followed by "inclination plus three point five." Meanwhile the book man repeats the measurements back as he writes them down and draws a scaled sketch of the passage. Onward goes the cave survey crew to get backsight measurements and other dimensions of the cave.

Cartographic survey—as indicated with the passage above—is a detailed inventory methodology used to study caves. Biologists and land managers are familiar with surface survey methods, but few are familiar with the techniques required to accurately create baseline maps of caves and other karst features. In addition to mapping, biological surveys and dye tracing studies are other important tools necessary for managers to use to accurately assess the biological, paleontological, archaeological, and geological wealth of caves, as well as guide their management.

Karst Feature Diversity and Management

Caves and other karst features are important components of Missouri's biological landscape, as well as in many other landscapes across North America. There is a tremendous diversity of cave types in Missouri and elsewhere. Just within the boundaries of Missouri, caves may be dry, fossil remnants of active streams, or they may contain large rivers. They may be immense shelter caves or they may be long natural tunnels. They normally have one entrance, but many have multiple entrances. Some of the largest caves in the state have entrances that are miles from each other. Most Missouri caves are developed in dolomite, but others are in limestone, sandstone, or even igneous rock. All harbor life of some sort; some contain rare and endangered species. All are delicate environments presenting challenges to land managers.

Like other natural communities, karst areas, particularly caves, are highly dependant on proper management. However, the proper management of karst systems sometimes eludes the grasp of many managers. Except for the surface components of sinkholes and springs, they are literally out of sight, which puts them out of mind.

Managing the cave environment is directly dependent on the management of the land above. However, most of our present land management, including that of natural areas, focuses only on the entrance of a cave. Forested buffers are put around cave entrances, gates are built, access is limited, and yet these basic and all too simplistic measures address only certain problems. All too often, we end up not managing cave systems, but people. Like people, caves cannot be pigeonholed into convenient management classifications. Since each cave is unique, management of each cave requires unique solutions. Further, successful management of caves and karst requires first-hand knowledge and experience of the resource; you simply cannot manage karst resources from a desk. Below are some tools to help managers.

Cave Mapping Tools

In order to properly manage a hidden resource, land managers need to know exactly what land units above and around a cave can effect its environment. Thus the first need is an accurate location of the entrance, followed by an accurate map showing the extent and nature of a cave. The former is easily obtained by a GPS device at the entrance.

The latter can be very difficult. The survey of Powder Mill Creek Cave, for example, an eight-mile long cave whose entrance is in a natural area, took nearly twenty years. Enterable only in the summer, the survey required participants to be well versed in cave survey, physically capable of crawling for miles in 56-degree water, and to have the experience necessary to avoid problems in a technical cave situation.

Cave radios, a pair of devices that allow voice and data communication through solid rock, are also useful for cave surveying. Utilizing these devices, cave managers can obtain

Kris Hartman

Urban cave entrance

Scott House

Cave radio work above ground...

Scott House

...and in a cave

exact GPS coordinates for points far from cave entrances and up to 300 feet below the surface of the land.

Data obtained from cave surveys are entered into computer programs and reduced to Cartesian coordinates. These are placed into a drawing program such as Adobe Illustrator, where they constitute a layer; another layer contains scans of the sketches. These layers provide the framework for a formal map that will be drawn over them. Both the map and the raw data can be placed into GIS systems as registered shape files. These shape files can be used to understand the extent of the cave system in relation to surface topography.

In Missouri, database information on cave locations, names, maps, and descriptions are maintained by the Missouri Speleological Survey, one of the nation's oldest state surveys. Some other states have similar organizations.

Biological Surveys

Biological surveys are important to understanding the cave's diversity. Collections are limited because cave environments can be fragile. Caves often surprise surface biologists because the survey results are unpredictable. Some very wet caves are biological deserts, while certain caves without active streams, like Branson Cave in Alley Spring Natural Area, are high on the biodiversity index. We simply don't understand all the factors influencing cave biodiversity. In Missouri, biological records from caves are entered into a database maintained by the Missouri Department of Conservation. From this, biodiversity indices can be determined.

Dye Tracing Studies

The humanly traversable section of a cave may not represent its full biological or hydrological extent. Many cave species are capable of living in the interstitial areas of rocks and sediment. The water that affects or travels through the cave may have come from an unknown distance. Dye tracing studies can help identify the watershed of a cave or spring system, but these studies are not cheap and a plan must be well developed in order to obtain useful results.

Land managers already have some of these tools available to assist them with cave management, such as knowledge of how surface hydrology, forest, and grassland restoration, or the placement of public use facilities can affect karst landscapes. But to fully assess and protect caves, land managers need to use the tools mentioned above and partner with organizations—such as those listed at the end of this article—that understand and study the cave environment. In addition, comprehensive cave management workshops that provide demonstrations on cave mapping, how to manage and interpret dye tracing studies, and how to help conduct biological surveys will help land managers obtain the information they need to make wise cave management decisions.

Cave Mapping in Perry County

CAVE MAPPING TOOLS
HELP PROTECT THE GROTTO SCULPIN

A.J. Hendershott

Grotto Sculpin

Brad Pobst

Perry County cave stream passage

In Perry County, Missouri, there are more than 650 documented cave entrances. Four of the county's caves are more than 15 miles long. In order to protect the cave species these caves harbor, particularly the rare grotto sculpin, the Missouri Department of Conservation (MDC) contracted with Cave Research Foundation (CRF) to create GIS layers showing the locations of cave passages. CRF and its partners obtained accurate entrance locations and digital photographs. They also scanned and brought older cave maps, which lacked raw survey data, into GIS. The largest caves required additional registry points in order to rotate the cave maps correctly into the GIS layers. Thus, cave surveyors made several trips with cave radios to obtain exact GPS coordinates for points far from the entrances and up to 120 feet below the surface. Locating these caves correctly helped MDC staff delineate hidden watersheds so that water quality protection measures can be implemented, which may help protect the grotto sculpin.

Scott House is president of the Cave Research Foundation. He is a past president of the Missouri Speleological Survey (MSS) and is currently data manager for the MSS' Missouri Cave Database. He has surveyed more than 500 caves in Missouri and other states and is currently a contracted cave management specialist.

Contact: Scott House, 1606 Luce St., Cape Girardeau MO 63701, Scott_house@semo.net, phone: 573-651-3782.

Additional Resources:
Cave Research Foundation: www.cave-research.org
Missouri Speleological Survey: www.mospeleo.org
National Speleological Society: www.caves.org
Karst Information Portal: www.karstportal.org

Saving Birds Across Landscapes and Ecosystems

Regional, national, and international plans like Joint Ventures help focus natural community management efforts for birds and all other wildlife.

By Jane Fitzgerald, Todd Jones-Farrand, and Lee O'Brien

www.billhubick.com

Cerulean warbler

THE BIRD CONSERVATION COMMUNITY began to undertake national and international-scale planning for waterfowl in the early 1980s, resulting in the completion of the North American Waterfowl Management Plan in 1985. This effort marked the first time state and federal land-managing agencies and non-governmental organizations came together to set range-wide population goals for non-endangered birds and agreed to work together to improve, protect, and restore adequate amounts of habitat needed to bring populations to desired levels.

This also marked the first time that conservation actions were planned to target specific landscape-scale geographies with biological relevance to waterfowl populations, focusing on breeding, wintering and migrating periods. Public-private partnerships like these, called Joint Ventures, were formed to implement conservation actions for waterfowl species in target areas, each having a coordinator and management board that set a strategic vision for, and cooperatively developed projects within, their respective regions.

Tom Nagel

American woodcock

In the 1990s, several other broad-scale partnerships like the North American Waterfowl Management Plan formed nationally and internationally to develop similar plans for landbirds, shorebirds, other waterbirds, bobwhite, and prairie grouse. These groups now are collectively represented by the North American Bird Conservation Initiative (NABCI). NABCI recognized the need to have a seamless, ecologically based geographic framework in which planning by different initiatives could be coordinated, and in response, they delineated Bird Conservation Regions that fully encompass North America (see www.nabci-us.org/map.html).

In addition, each national and international plan now has a list of priority bird species that can be "stepped down" to the scale of one or more Bird Conservation Regions, and most of these initiatives at least have species-specific, range-wide population objectives. Since the inception of NABCI, the Joint Ventures that originally formed under the auspices of the North American Waterfowl Management Plan have been expanding their capacity to take responsibility for "all birds" of conservation concern, and new Joint Ventures have formed to cover those areas where none previously existed. Joint Ventures are now experimenting with a variety of habitat and population modeling approaches to better understand how bird population numbers are linked to habitat quantity and quality, in an attempt to step range-wide population targets down to the scale of Bird Conservation Regions.

The Central Hardwoods Joint Venture

The Central Hardwoods Joint Venture focuses planning and implementation efforts on the Central Hardwoods Bird Conservation Region, encompassing the Ozarks Ecoregion to the west of the Mississippi River, and the Interior Low Plateaus Ecoregion to the east. The Central Hardwoods' priority bird species (see Table 1) once were associated with a wide array of natural communities, from mesic and bottomland forests, through open woodlands and glade complexes, to barrens, savannas, and prairies—most of which have been converted to other land uses or have been degraded by widespread logging, over-grazing, and the suppression of fire during the 20th century. While these species persist today in association with current land use types and conditions, the Central Hardwoods Joint Venture partnership believes that restoration of native ecosystems in large and appropriate landscapes not only will improve the health of native bird populations, but will benefit other organisms whose populations have declined due to the loss of these native habitat types as well.

Central Hardwoods Joint Venture staff has recently developed priority bird species habitat suitability models in conjunction with land cover and potential natural community maps. Staff then examined how combinations of acreages of different natural community types would affect changes in the populations of priority bird species. Restoration of even large percentages of mixed oak-pine and closed oak woodlands had little projected impact on any priority species. However, restoration of 15 percent of the historic acreage of prairie/savanna and barrens, glade/savanna/woodland complexes, and open oak woodlands, and 20 percent of open pine-bluestem woodlands appears to be of great benefit to four high priority species—blue-winged warbler, prairie warbler, brown-headed nuthatch, and Bachman's sparrow—the latter two of which are nearly extirpated from the Bird Conservation Region.

MDC

Blue-winged warbler

Stay tuned as Central Hardwoods Joint Venture staff plans to validate and refine the models used in this exercise, and to put monitoring procedures in place as restoration proceeds to insure that principles of adaptive management will be applied. However, this marks the first attempt that we're aware of to quantify projected changes in bird populations from natural community restoration across large landscapes. We are hopeful that advancements in modeling and GIS applications will yield even more and better information for birds and other taxa of conservation concern in the coming years.

Jane Fitzgerald, Ph.D., is the Central Hardwoods Joint Venture Coordinator; Todd Jones-Farrand, Ph.D., is the CHJV Science Coordinator; and Lee O'Brien is the CHJV GIS Analyst. Jane and Todd are employed by the American Bird Conservancy; Lee is an independent contractor.

Contact: Jane Fitzgerald, 8816 Manchester Road, Suite 135, Brentwood, MO 63144, jfitzgerald@abcbirds.org, phone: 314-918-8505.

Additional Resources:
www.nabci-us.org/map.html
Central Hardwoods Joint Venture: www.chjv.org

MDC

Henslow's sparrow

TABLE 1. CENTRAL HARDWOODS JOINT VENTURE PRIORITY BIRD SPECIES

Forest-Woodland	Grass-Shrubland	Grassland	Wetland
Red-cockaded woodpecker (extirpated)^*	Blue-winged warbler*	Greater prairie-chicken*	Swallow-tailed kite (extirpated)*
Brown-headed nuthatch^*	Prairie warbler*	Short-eared owl*	King rail*
Cerulean warbler*	Painted bunting*	Bell's vireo*	Least tern*
Swainson's warbler*	Bell's vireo*	Henslow's sparrow*	American black duck*
Bachman's sparrow^	Bewick's wren	Loggerhead shrike	Horned grebe*
American woodcock*	Northern bobwhite	Sedge wren	Swainson's warbler
Red-headed woodpecker*	Eastern kingbird	Lark sparrow	James Bay Canada goose*
Wood thrush*	White-eyed vireo	Grasshopper sparrow	Cerulean warbler*
Worm-eating warbler*	Brown thrasher	Northern bobwhite	Prothonotary warbler*
Kentucky warbler*	Yellow-breasted chat	Eastern kingbird	Lesser scaup
Ruffed grouse	Eastern towhee	Eastern meadowlark	Pied-billed grebe
Yellow-billed cuckoo	Field sparrow		American bittern
Whip-poor-will	Orchard oriole		Least bittern
Blue-gray gnatcatcher			Yellow-crowned night-heron
Eastern wood-pewee			American coot

^denotes pine woodland specialists *species of continental concern

Missouri Natural Areas: What Role Conservation Easements?

By Edward J. "Ted" Heisel

LAND TRUSTS AND THE CONSERVATION EASEMENTS they hold have grown dramatically both in number and scale over the past thirty years. Many land trusts around the country have become real forces for conservation and valued institutions within their communities. The likelihood of continued growth in this conservation sector merits additional consideration by natural area managers as to how land trusts and easements can be integrated into natural area protection.

So what is a land trust anyway? In Missouri, I suspect most people stopped on the street would still offer a guess that it is an investment vehicle or estate-planning tool. According to the Land Trust Alliance, "a land trust is a nonprofit organization that, as all or part of its mission, actively works to conserve land by undertaking or assisting in land or conservation easement acquisition, or by its stewardship of such land or easements."

As this broad definition implies, land trusts span a wide spectrum in terms of their focus. Large, national, and international organizations like The Nature Conservancy usually are counted as land trusts, but there is a separate phenomenon of local and regional organizations protecting green space, farmland, and wildlife habitats closer to their home. The most recent land trust census conducted by the Land Trust Alliance in 2005 showed that local and regional organizations had protected a total of 12 million acres throughout the country. The updated census that will occur this year will certainly show a vast increase in these numbers.

Without wanting to denigrate my own organization—the Ozark Regional Land Trust—or home state too much, I think Missouri has to be placed in the bottom quartile of states when it comes to land trust activity and capacity. It is estimated that national, regional, and local non-profit organizations hold conservation easements on about 30,000 acres in Missouri, a relatively modest accomplishment compared to what has been done in many other states. The pace here has been quickening in recent years, but we can still do more.

Benefits and Limitations of Land Trusts to Natural Area Protection

What is the role of land trusts in relation to protection of the state's natural areas, that is, those prime exemplars of Missouri's native biological communities or geologic features? Conservation easements clearly can play a role, but it is also important to consider their limitations when assessing where and how to use them.

One thing conservation easements can do well is prohibit or limit land uses that threaten serious harm to native ecosystems. The central components of most conservation easements are limitations on development and standards for natural resource management.

Thus, a typical conservation easement on a 500-acre tract of forest in the Ozarks might limit development to one or two "building envelopes." These envelopes—usually three to five acres in size—become the boundaries for future development. This limitation leaves the vast majority of the land protected for sustainable timber harvesting and wildlife habitat.

Standards for natural resource management are another key component of most easements. Drafting such standards for *perpetual* easements is, however, a difficult task. The key is to strike a balance between definitive restrictions that can be enforced, on one hand, and flexibility to allow for changing conditions and evolving management practices, on the other. Land trusts have devised a wide array of approaches to writing conservation easements for forestland, most of which have as their central component a requirement that harvesting on the land follow a management plan prepared by a professional forester.

So conservation easements are pretty good at protecting land from development and imposing reasonable limitations

Conservation Easements and Natural Areas Protection Workshop

Author Ted Heisel will lead the Conservation Easements and Natural Areas Protection workshop at the 37th Annual Natural Areas Conference on October 29. The workshop will explore the use of conservation easements for the protection of natural areas. Workshop leaders—including practitioners in the field, natural area biologists, managers and a landowner—will review the past, present, and future use of conservation easements throughout the United States, highlighting current issues concerning their use. Specific terms of conservation easements will be discussed to demonstrate the benefits and limitation of using them to protect natural communities.

Ted Heisel

Conservation easements held by private land trusts protect approximately 30,000 acres in Missouri, including this stretch of Bryant Creek in Ozark County.

on natural resource extraction. What they are not so good at is requiring affirmative management of ecosystems, such as prescribed fire or invasive species removal.

It is a much more difficult proposition to impose a perpetual obligation on a landowner to assemble a fire-crew for regular prescribed burns than it is to simply restrict the building of a strip mall. Active management practices require a landowner to take affirmative steps and spend money that they may not have. In some situations, there would be no feasible mechanism to enforce such requirements.

It is probably a better approach from a land trust's perspective to work with landowners who may have a conservation easement on their land to voluntarily implement restoration practices or to help them access the cost-share programs that make such practices more feasible.

The bottom line is that a conservation easement *by itself* may not be the best tool for protecting the core of a natural area that requires active management (e.g., a fire-adapted prairie, glade, or savanna). However, conservation easements are well suited to preventing harmful change in natural areas requiring little or no active management (e.g., old growth forest, cave, or spring habitats).

Conservation easements can also be effective tools for buffering natural areas from external influences or maintaining corridors for wildlife migration. Having a working forest or ranch adjacent to a natural area is in most cases better than a subdivision or commercial development. Moreover, pristine habitat is often not required to allow species dispersal between core wildlife areas.

Increasing the Role of Conservation Easements in Missouri

What will it take for land trusts and conservation easements to play a bigger role with regard to natural area protection in Missouri? Clearly, one thing is increased capacity among the state's land trusts. Focusing on specific areas with high quality natural features requires having trained staff and an ability to conduct landowner outreach in those areas of greatest importance.

Another need is project funding. While conservation easements—particularly donated ones—require a much lower up-front investment than fee title acquisition, there are still costs involved. A land trust is taking on a perpetual responsibility when it accepts a conservation easement; responsible land trusts deposit money into a dedicated, long-term stewardship fund with each new project. There are also lesser setup costs such as preparing baseline condition reports, staff time negotiating easement terms, and title work.

The Ozark Regional Land Trust has worked closely with the Missouri Department of Conservation in recent years to protect high priority forests and wildlife habitats around the state. This has been a good partnership that has generated significant conservation results. A similar model could be followed with regard to natural areas or, for that matter, state parks, national wildlife refuges, or other public lands.

Ted Heisel

David Hartig on his land in Dent County.

Protecting the Headwaters

Landowner David Hartig has acquired significant landholdings in the upper Current River watershed over the past two decades. Hartig values the land as a peaceful retreat as well as a source of income. He is in the forest products business, primarily producing wooden poles for fencing from shortleaf pine.

In 1999, Hartig began donating conservation easements to the Ozark Regional Land Trust on some of his land in Dent and Texas Counties. Over time, he has permanently protected nearly 2,000 acres with conservation easements. These easements allow the land to be used for sustainable timber production, but greatly limit future development.

This land lies in a key area for conservation in the Ozarks: the headwaters of the Current River just upstream of Montauk State Park. Maintaining forest cover on this land helps ensure that the Current will continue to run clear as it passes through thousands of acres of state and federal parks, state conservation areas, and other private lands dedicated to conservation.

This type of land buffering, thanks to conservation easements, could be used elsewhere in the future to protect Missouri's natural areas from external threats.

Edward J. "Ted" Heisel is Executive Director of the Ozark Regional Land Trust. ORLT is a land trust that serves the Ozark region, with projects in three states that protect more than 21,500 acres of land. Heisel's previous experience includes serving as clinic attorney at the Washington University Interdisciplinary Environmental Clinic in St. Louis and as Executive Director of the Missouri Coalition for the Environment.

Contact: Edward J. "Ted" Heisel, Executive Director, Ozark Regional Land Trust, P.O. Box 440007, St. Louis, MO 63144, ejheisel@orlt.org, phone: 314-401-6218.

Additional Resources: Land Trust Alliance: www.lta.org
McLaughlin, N.A. 2002. The Role of Land Trusts in Biodiversity Conservation on Private Lands. Idaho Law Review 38:453–469.
Ozark Regional Land Trust: www.orlt.org
Rissman, A.R. 2007. Conservation Easements: Biodiversity Protection and Private Use. Conservation Biology 21:709–718.

Resistance, Resilience, Response, and Realignment

Climate Change Demands Adaptable Natural Community Professionals

By Dennis Figg

WHAT WILL FISH AND WILDLIFE POPULATIONS NEED in the face of climate change? Most of all, future wildlife will be sustained by a connected network of lands valuable to wildlife, managed by a conservation community that practices adaptive resource management. Managers of natural systems will be challenged to respond much as they have in the past, but through the lens of climate change. That climate is changing is no longer a debate, but the speed at which change may occur is uncertain, and the impact to specific locations is very uncertain.

Perhaps our first challenge when confronting climate change is to agree that natural systems are highly dynamic. The notion that natural ecosystems are relatively stable, self-regulating, and reasonably predictable is a common perception, particularly in the fish and wildlife community where predicting species response is a regular exercise. But as David Cole and his co-authors have written in *Naturalness and Beyond: Protected Area Stewardship in an Era of Global Environmental Change*, natural systems are highly dynamic; the idea that natural systems are stable, self-regulating systems operating in equilibrium is erroneous.

The Four "Rs" of Climate Adaptation

Under increasingly dynamic alterations to the climate, will natural community managers become facilitators of change or resist change? Fish and wildlife managers are being trained to evaluate management options in four categories: resistance, resilience, response, and realignment. Resistance strategies are designed to forestall or prevent undesired effects so that natural systems can resist change. Resilience strategies promote viability of system health, assuming that the community will be healthy enough to accommodate gradual changes and/or return to prior conditions at a later time. Response is actively or passively facilitating ecosystem changes. Realignment strategies rethink and implement restoration and management for current and anticipated future conditions.

Many species managers appear to be caught up in only resistance strategies: How do I keep this species in this specific place in abundance? The problem with this approach is that if the conditions for which a species is adapted (the "environmental envelope") changes, the species cannot live there anymore. Using a contemporary example, hikers in the Colorado Mountains have observed that picas no longer occur at elevations where they formerly occurred. The environment has changed—despite anyone's best efforts to maintain the ecological integrity of this pica habitat—and the picas can no longer live at lower elevations.

When are we, as *natural community managers*, caught up in resistance strategies? In general I believe that we are more flexible, that we manage associations of plants and animals rather than specific species. But we too relate to and emphasize particular members of a community, resisting their decline or loss, and resisting the introduction of a new plant or animal. Our glades are a good example. We want to keep collared lizards viable, although their arrival to the Ozarks occurred during a time when the Ozarks was much drier—a time of different climate. This species is a "relict" in the same way that the cherrystone snail in Boone County, Missouri, is a relic of glacial times. Is a glade without collared lizards still a glade community?

Saving All the Parts— Or Saving a Place for the Parts?

One of our strengths is that we appreciate that the diverse natural communities of Missouri, with many moving parts, are the result of expansions and contractions, gains and losses, from many different climate histories. I've always been a champion for "saving all the parts." But that becomes more difficult, especially if the change in climate occurs more quickly than individual species can adjust to. Virginia Burkett, Chief Scientist for Global Change Research at the U.S. Geological Survey, who also works with the Intergovernmental Panel on Climate Change, suggested that, "Unless all components of the ecosystem change at the same rate, the systems will decouple and the new systems may bear little resemblance to the ecosystems to which managers are accustomed."

At some point we become managers of change whether we want to be or not. Familiar plants and animals of existing natural communities are removed from the system or greatly diminished. Wolves are no longer a predator in Ozark forests. The natural community reorganizes itself. Unfamiliar plants and animals arrive. They can be native, like the recent expansion of armadillos, or exotic, like the Asiatic clam brought to North America by Asian immigrants in the 1920s. Now abundant in most Ozark streams, many people assume these mollusks are a native member of our aquatic fauna. New plants and animals also reorganize the natural community. Different regimes of the same disturbances (floods, fires, droughts) that form and sustain natural communities also reorganize natural communities.

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A connected network of healthy forest communities will help species like the ringed salamander, an Ozark endemic, survive effects of climate change on the landscape.

I think the point is, the natural communities we are managing have been reorganizing all along. Will climate change "trump" the present natural communities represented by our natural areas system? I don't think so, at least in the near term. Natural community managers, already sensitive to dynamic ecosystems, will continue to monitor change and make observations that will help demonstrate "reorganization" of the plants and animals. As there are new arrivals, do we fight them off? As some of the old recognized members of natural communities decline, do we bolster their populations? Both are resistance options. Perhaps the four management options are not so much different choices, but different strategies along one continuum. It may well be important to resist today (e.g., fight cedar invasion on glades) but move to a different strategy in the future, recognizing when it's time to take a different approach.

Restoration of cropland to floodplain forests around Donaldson Point Natural Area in New Madrid County, Missouri, may be a good example. Our expectation, even with current climate predictions, is that this landscape will continue to be a forest community with floods and sedimentation and natural processes that promote conservative species like Swainson's warblers, mole salamanders, swamp rabbits, and giant cane. While we understand the present composition of plant and animals very well, the timing and duration of flooding has changed and the plant community is changing. But as we reduce forest fragmentation by restoring cropland back to floodplain plants, what is the best composition and abundance for the future forest? While Donaldson Point provides a good baseline, restoration is not likely to recreate a perfect replacement of the previous forest. The best we can hope for is a restored community of plants and animals that function much like the previous forest community. Climate change becomes another management consideration, but conserving the existing forest and building a support system around it is still a relevant conservation initiative.

Climate change is challenging all of us to rethink natural community composition. Some systems will be more impacted than others; perhaps the conservative approach is to consider all of them vulnerable. Even when some of the changes on the landscape make us uncomfortable, we must remember that the management choices we make now and in the future will shape the reserve network for future wildlife.

Dennis Figg is a Wildlife Programs Supervisor for the Missouri Department of Conservation (MDC). His work involves implementing a habitat conservation system for future wildlife. Dennis teaches Strategic Habitat Conservation to fish and wildlife agency staff around the country. He is also a member of the MDC Climate Change Working Group, the Association of Fish and Wildlife Agencies Climate Change Committee, and the National Council for Science and the Environment, Wildlife Habitat Policy Research Program.

Contact: Dennis Figg, Wildlife Division, Missouri Department of Conservation, P.O. Box 180, Jefferson City, MO 65102-0180, Dennis.figg@mdc.mo.gov, phone: 573-522-4115 ext. 3309.

Additional Resources:

Voluntary Guidance for States to Incorporate Climate Change into State Wildlife Action Plans & Other Management Plans. A Collaboration of the Association of Fish & Wildlife Agencies' Climate Change and Teaming With Wildlife Committees, *September 2009*. Available at www.fishwildlife.org/agency_science.html.

Climate Change and Conservation: A Primer for Assessing Impacts and Advancing Ecosystem-based Adaptations in The Nature Conservancy March 2010. Published by The Nature Conservancy

Harris, J. A. et al. Ecological Restoration and Global Climate Change. 2006. Restoration Ecology 14 (2):170–176.

Climate Change 2007: Synthesis Report, Summary for Policymakers, Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Core Writing Team, Pachauri, R.K. and Reisinger, A. (Eds.), IPCC, Geneva, Switzerland. See www.ipcc.ch, Publications and Data page.

Recent Missouri Natural Area Designations and Removals

Changes Highlight the Continued Evolution of the Missouri Natural Areas System

By Mike Currier and Mike Leahy

ADDING AND REMOVING NATURAL AREAS from the Missouri Natural Areas System is an iterative process necessary to strengthen the integrity of the natural areas program. Designations and removals also both broaden and refine the guidelines for natural area management by bringing to light new management problems, such as new arrivals of exotic species, and new management tools and techniques, such as utilizing commercial thinning for woodland restoration.

In the early years of the Missouri Natural Areas Program, natural areas were small and focused on designating the very best natural communities known at the time, regardless of size or relevance to broader landscape configuration. Management efforts tended to be custodial. By the 1980s, natural area biologists realized the importance of simulating natural disturbances, such as fire. At the same time, invasive, exotic species began to become a serious issue.

By the 1990s, natural area biologists realized that the restoration and management of larger areas of natural communities were important. Biologists also began to realize that some natural areas designated at the beginning of the program were not truly representative of specific natural communities. Over the past decade, the adoption of new GIS tools and the development and refinement of both terrestrial and aquatic ecological classification systems provided new methods for analyzing and evaluating sites for their natural area potential.

These new tools and more than 20 years of natural community restoration and management experience led to substantial evolution in the concepts of acceptable management practices for Missouri Natural Areas and how natural area boundaries should be designated. This has recently culminated in the development of a set of peer-reviewed Missouri Natural Area Management Guidelines by the Missouri Natural Areas Committee (MoNAC) scheduled for release in the fall of 2010. The natural area actions below—and the questions debated by committee members to arrive at these actions—influenced the development of these guidelines by providing insight on the design of larger landscape-scale natural areas, led to better techniques for identifying and nominating aquatic natural areas, facilitated the incorporation of forestry practices into woodland restoration, and established what criteria are used to delist a natural area from the system.

Prairie State Park Photo

Regal Tallgrass Prairie NA

Regal Tallgrass Prairie Natural Area is a 3,646-acre site at Prairie State Park in Barton County managed by the Missouri Department of Natural Resources. This natural area was designated in August 2008 and combines four previously designated natural areas into a large working landscape dedicated to the restoration of tallgrass prairie. Fourteen percent of the site—about 525 acres—is considered buffer land to the high quality prairie remnants and includes some reclaimed strip mines and former agricultural lands, all part of the watershed of East Drywood Creek, an Outstanding State Resource Water. When the Missouri Natural Areas Committee discussed the nomination, questions arose about preserve design and the number of acres included as buffer: How much buffer is acceptable? How do we represent the area to the public when degraded communities are included within the natural area boundaries? Does this compromise the integrity of the natural areas program? What is the role that interpretation plays in natural area designation?

For this area the committee supported including buffer lands, contingent on ongoing prairie restoration and an active outreach and education program. The Natural Resource Management Plan for Prairie State Park encompasses the entire park, meaning that all areas are under active

MDC

Spring Creek Ranch NA

management. Natural area designation strengthens this commitment by placing a stronger emphasis on active preservation, recognizing the managing agency has the ways and means to maintain the values represented by the designation. The management recommendations in the nomination serve as an agreement to protect the values detailed in the designation.

Is it better to complete restoration prior to natural area designation, or to designate while restoration is in process? The ongoing work of management and restoration is an integral part of natural area designation. It is an active, dynamic process. The key is to have an interpretive program that effectively communicates these values to the public. Prairie State Park has a visitor center and interpreters that provide site-based outreach and educational programs.

Spring Creek Ranch Natural Area is a 1,769-acre site at Union Ridge Conservation Area (CA) in Sullivan and Adair Counties managed by the Missouri Department of Conservation (MDC). Designated in September 2009, this natural area conserves a prairie headwater stream system and the largest savanna remnant in the Central Dissected Till Plains of Missouri. The natural area encompasses more than 80 percent of the watershed of a prairie headwater stream, which supports 19 fish species, including the brassy minnow, a species of conservation concern.

There is a core area of 150 acres of high quality savanna on the natural area, but the bulk of the acreage is still responding to the process of restoration and is currently of moderate natural quality. The ideas behind designating this larger watershed-scale natural area are to highlight and protect the prairie headwater stream system and to recognize the potential of the site as demonstrated through 10 years of management. In time, Spring Creek Ranch has the potential to become the signature savanna landscape of the Central Dissected Till Plains.

Spiderlily Natural Area is a 354-acre site at Mudpuppy CA in Ripley County managed by the MDC and was designated in January 2008. This natural area was designated primarily for its aquatic natural community, the Little Black River, and was the first such designation in many years. The design was broadened to include the entire riparian corridor of the Little Black River as it flows through the CA. The use of both Missouri Natural Heritage Program data (tracking natural communities and species of conservation concern) and data from the Missouri Aquatic Ecological Classification System (developed by the Missouri Resource Assessment Partnership or MoRAP) helped to guide this designation. In particular, information on the Aquatic Human Threat Index (see page 6) for the Little Black River developed by MoRAP was salient in the selection process for this natural area.

Razor Hollow Natural Area is a 923-acre site at Daniel Boone CA in Warren County managed by the MDC and designated in January 2008. This area features a characteristic Ozark Border landscape. Its designation was initially controversial because parts of the forests and woodlands included sites that had been recently commercially harvested as part of an uneven-aged silvicultural practice designed to create canopy gaps and historic tree stocking conditions. This silvicultural practice was combined with non-commercial understory thinning and prescribed fires. The debate surrounding this nomination led to MoNAC adopting guidelines on the use of commercial timber harvests for restoration purposes on natural areas.

Burr Oak Woods Natural Area and Big Buffalo Creek Forest Natural Area were both small natural areas (33 and 6 acres, respectively) managed by MDC that were designated more than 25 years ago (predating the Missouri Natural Features Inventory). These sites were removed from the system in December 2009. Today these sites are no longer considered viable, high quality representatives of the natural communities they were originally nominated to represent. Having such poor quality examples in the system weakens its integrity.

Twenty-Five Mile Prairie Natural Area, a 120-acre, high quality remnant of limestone prairie in Polk County managed by MDC, was recently added to the natural areas system. Tallgrass prairies are rare in Missouri and remnant prairies with a soil derived from limestone are even rarer, as most remnant prairies are on sandstone deposits. Twenty-Five Mile Prairie NA is number 180 of a 70,759-acre system of protected lands and waters.

Mike Currier and Mike Leahy are Natural Areas Coordinators for the Missouri Department of Natural Resources and the Missouri Department of Conservation, respectively.

Contact: Mike Currier, Missouri Department of Natural Resources, Division of State Parks, P.O. Box 176, Jefferson City, MO 65102, mike.currier@dnr.mo.gov, phone: 573-526-2990.

Mike Leahy, Missouri Department of Conservation, Wildlife Division, P.O. Box 180, Jefferson City, MO 65102-0180. Michael.leahy@mdc.mo.gov, phone: 573-522-4115 ext. 3192.

Not Enough Botanists!

Workshop assesses need for botanists in the United States

By Nancy Morin

The Chicago Botanic Garden and Botanic Gardens Conservation International co-organized a workshop to help assess botanical capacity in the U.S., held at Chicago Botanic Garden on September 29 and 30, 2009. The workshop included approximately 40 participants from academic, governmental, and non-governmental organizations and agencies including the federal government, universities, botanical gardens, professional societies, the Flora of North America Project, and NatureServe. The workshop was part of a one-year grant-funded project. Its purpose was to discuss results of a nationwide survey of the collective ability of U.S. institutions and individuals to advance plant science education, research, and application; to identify gaps in capacity; and to recommend a plan of action to fill those gaps.

At the time of the workshop, the survey, which was conducted online with invitations to participate widely distributed within the botanical community, had resulted in 1,141 responses. Additional professional groups were still being invited to participate. Responses were analyzed by Barbara Zorn-Arnold, research associate at Chicago Botanic Garden, according to their category of work (government, non-government, academic). The workshop participants discussed the following preliminary findings:

- Almost 40 percent of the faculty surveyed indicated that botany courses, primarily botany, taxonomy, and ethnobotany, had been eliminated at their institutions. Graduate students said that field botany, restoration ecology, and biogeography courses should be added. Federal government and non-government organizations said botanical resources needed to meet their goals were lacking. Botanists were identified as the staff and faculty most needed across all groups. Lack of botanical resource was considered to be due to lack of financial support as well as lack of available staff time.
- Of the faculty respondents, 30 percent said they taught a botany course, and 20 percent said they taught field botany. Nearly 17 percent said no botany classes were offered in their department; respondents indicated that the number of full-time botany faculty had decreased whereas the number of part-time positions had increased in their department. Botany, ecology, and systematics were identified by 20 percent as the top three fields most needed in their department.
- When asked to name their top three choices for employer, graduate students selected botanic gardens, universities and colleges, or conservation-based NGOs as one of their top three, although 41 percent said universities were their first choice. The top three areas they thought would have the most job openings were climate change, horticulture, and plant genetics.

Carol Davit

Field botany class on a Missouri prairie.

- Botanists in the federal government chose lack of staff with appropriate botanical training, lack of research materials, and lack of financial support as the top three resources limiting their agency in its plant conservation and management responsibilities. A total of 90 percent said they did not have enough botanically trained staff to meet their needs. A total of 80 percent said lack of perceived need within their agency was the main obstacle.
- The workshop participants discussed strategies to address this lack of botanical capacity. They concluded that efforts were needed (1) to increase public understanding of the importance of plants in the environment and the need for botanists who study and can increase our understanding of plants; (2) to urge the establishment of more botany positions within government agencies and NGOs; and (3) to use whatever leverage was available to encourage academic institutions to maintain or increase the courses they offer in basic botany, field botany, and systematics.

For more information about the survey and results, contact Andrea Kramer, Executive Director, BGCI-US, Chicago Botanic Garden, andrea.kramer@bgci.us.org. A series of workshops funded by the National Science Foundation to assess capacity in systematics across all organismal fields is also underway. For more information contact Patrick Herendeen, Chicago Botanic Garden, pherendeen@chicagobotanic.org.

Nancy Morin is a plant taxonomist specializing in Campanulaceae. She has been on staff at the Missouri Botanical Garden, American Public Gardens Association, and the Arboretum at Flagstaff, AZ. She is currently an author, editor, and business manager for the Flora of North America Association.

Contact: Nancy Morin, Flora of North America Business Office, P. O. Box 716, Point Arena, CA 95468, Nancy.Morin@nau.edu, phone: 707-882-2528.

Additional Resources: Read the survey report in brief at www.bgci.org/files/UnitedStates/BCAPReportInBriefGov.pdf. Botanic Gardens Conservation International also sent a letter to the U.S. Office of Science and Technology Policy in response to a nation-wide request for information on grand challenges of the 21st century. Read the letter at www.bgci.org/files/UnitedStates/OSTPgrandchallengesRFI_botanicalcapacity.pdf.

Revised *The Terrestrial Natural Communities of Missouri* Is Available

The 2010 edition of *The Terrestrial Natural Communities of Missouri* by Paul Nelson is now available to land managers and anyone else interested in nature and Missouri's landscapes.

The classification system, first published in 1985, was extensively revised and reprinted in 2005 with more than 300 color photographs in the 500-page publication. The 2010 revised edition includes 35 new color photographs and updated information in several chapters, charts, and graphics. The text gives detailed descriptions of Missouri's terrestrial natural communities, including forests, woodlands, savannas, prairie, glades, cliffs, stream edges, wetlands, and caves. Updated examples of where you can still see these communities today are provided along with information on the communities' conservation status, threats, and ecological restoration. The list of designated Missouri Natural Areas as of February 2010 is included as well.

The book is being published by the Missouri Natural Areas Committee and is being reprinted by the Missouri Department of Natural Resources with financial and technical assistance from the Missouri Department of Conservation. The cost is $34.95 plus taxes, shipping, and handling fees. For more information about ordering the book, contact the Missouri Department of Natural Resources at 800-334-6946 or at moparks@dnr.mo.gov.

Coming this Fall: *Discover Missouri Natural Areas—A Guide to 50 Great Places*

The Missouri Natural Areas System protects the best remaining examples of our state's natural heritage. Now, a great new book is in the works to help nature lovers experience these special places firsthand: the Missouri Department of Conservation's *Discover Missouri Natural Areas—A Guide to 50 Great Places*. In this beautiful, user-friendly guide, author Mike Leahy, the Department's natural areas coordinator, offers natural history information that brings to life the geological, biological, and ecological features of each area, owned by various agencies and other landowners. Easy-to-use maps and stunning photographs compliment the text.

Watch for an announcement in the *Missouri Conservationist* and at www.MissouriConservation.org (natural areas page) to learn when the guide will hit bookshelves.

MDC

Hikers explore Stegall Mountain Natural Area, one of 50 sites featured in the new guidebook.

Missouri Master Naturalist™

Barbara Kipfer

Missouri Master Naturalist Program

Volunteers at the ready to help with natural area management!

When Barbara and Bob Kipfer visited La Petite Gemme Prairie Natural Area and saw sericea lespedeza about to set seed, they knew quick action was needed. Members of the Springfield Plateau Chapter of the Missouri Master Naturalists, Barbara and Bob had attended a training session in September 2009 for the chapter's new class at this 37-acre Missouri Natural Area in Polk County owned by the Missouri Prairie Foundation.

Barbara, who has seven years of—as Bob calls it—"extensive and compulsive experience in elimination of invasive species," noted an early invasion of the aggressive exotic sericea lespedeza. Bob contacted the Missouri Prairie Foundation and offered to treat the plants with herbicide; his generous offer was accepted with no hesitation!

Natural area managers with volunteer projects, such as invasive species removal, species monitoring, seed collection, natural area sign posting, trail construction, tree planting, or special management work days can ask for Missouri Master Naturalist assistance. Contact Syd Hime, Missouri Master Naturalist Program Coordinator, at 573-522-4115 ext. 3370 or syd.hime@mdc.mo.gov.

Johnson's Shut-Ins State Park Reopens

Johnson's Shut-Ins Natural Area has been restored. Johnson's Shut-Ins Fen Natural Area, also within the park, continues its slow recovery.

The grand reopening ceremony for Johnson's Shut-Ins State Park near Lesterville was held Saturday, May 22, 2010. The ceremony marked the first time the entire redeveloped park had been open since December 2005, when the Taum Sauk Reservoir breached and damaged the main use area of the park.

Following the breach in 2005, the Missouri Department of Natural Resources began an extensive environmental cleanup effort. Trees, sand and clay, sometimes eight feet deep, covered the main use area of the park, including the fen. More than 1,500 truckloads of sand and debris were removed from the fen alone. Much of it had to be done by hand to protect the sensitive fen plants. The fen, which comprises the **Johnson's Shut-Ins Fen Natural Area**, continues its slow recovery. The water created a dam on the East Fork of the Black River and that had to be removed. The river was rebuilt with the help of experts from several agencies, including the Missouri Department of Conservation and the Natural Resources Conservation Service. The shut-ins, which make up the **Johnson's Shut-Ins Natural Area**, were also filled with sand and debris that had to be removed.

Mike Leahy

Widely known and loved for its shut-ins on the East Fork of the Black River, Johnson's Shut-Ins State Park also protects Johnson's Shut-Ins Fen Natural Area, pictured here.

Eugene Vale

MoNAC member Ken McCarty, chief of the Natural History Section for the Division of State Parks, Missouri Department of Natural Resources, led a tour during the grand opening of Johnson's Shut-Ins State Park. In the background is the new Black River Center, an orientation facility for the park.

The river valley is now a day-use area with trails, picnic areas, and access to the East Fork. The boardwalk to the shut-ins has been rebuilt for easy access. On May 22, the new Black River Center opened for the first time. This orientation center for the park includes exhibits on the natural and cultural history of the park as well as a small gift shop.

The campground was moved out of the valley into the nearby Goggins Mountain area and opened to the public on April 30. The new campground includes a variety of campsites, including walk-in sites, sites with electricity/water/sewer, and a special equestrian loop. The campground also includes six new camper cabins.

For more information on the park, go to mostateparks.com.

New Missouri Natural Areas Directory on the Web!

The Missouri Department of Conservation's Web site is undergoing a redesign that will go public in July 2010. As part of this Web redesign, the Missouri Natural Areas Directory will now be available as an on-line document. The new Natural Areas Directory will replace the very outdated 1996 directory that is now out of print. The new directory will be located on a mini-site on the Conservation Department's home page. Go to www.MissouriConservation.org then navigate to the Discover Nature page. Here you will find the Natural Areas Directory under the Places to Go section.

The new directory will feature the highlights, natural history, access information, maps, photos, and more for all of the designated natural areas open to public visitation, over 150 natural areas in all. In addition there will be background information on natural communities, the Missouri Natural Areas Program and Committee, natural areas stewardship, guidelines for visiting natural areas, and links to partner agencies and organizations involved with the conservation of Missouri's designated natural areas. Initially the top 50 natural areas in the state will be highlighted with expanded information, and by October 2010, the directory will be completely up-to-date.

Two MoNAC Members Receive MONPS Awards

On June 5, at the annual meeting of the Missouri Native Plant Society (MONPS) Dr. Paul McKenzie, Endangered Species Coordinator with the U.S. Fish and Wildlife Service in Columbia, and Mike Leahy, Natural Areas Coordinator with the Missouri Department of Conservation, were recognized for their contributions toward protecting and promoting the state's flora.

Paul's award, the John E. Wylie Service Award, was presented "for sustained exceptional service in various leadership roles and active membership of 20 years" in MONPS. Paul was honored for having conducted numerous grass and sedge workshops for the group, as well as having led numerous botanical field trips over two decades, all of which have contributed to collective knowledge about Missouri's plant resources.

Mike received the MONPS Plant Stewardship Award, presented "for leadership and innovation in protecting Missouri's Terrestrial Natural Communities and the Conservation of our Native Flora." Mike was recognized for his work to promote, protect, and restore natural communities, thereby helping to protect native flora.

From left are Dr. Paul McKenzie; Steve Buback, member of the MONPS Nominating Committee; and Mike Leahy.

MONPS is a group of about 350 amateur and professional botanists that was formed in 1980 with the purpose of promoting the enjoyment, preservation, conservation, restoration, and study of the flora native to Missouri; educating the public about the values of the beauty, diversity, and environmental importance of indigenous vegetation; and publishing related information. For more information on the group, see http://www.missourinativeplantsociety.org/.

Exotic Plant Control Efforts at the Ozark National Scenic Riverways

The Ozark National Scenic Riverways is working with the Heartland Inventory and Monitoring Network (HTLN) in an effort to help control exotic plants within the park. HTLN is part of the nationwide Inventory and Monitoring program of the National Park Service, which has organized its parks with significant natural resources into 32 Inventory and Monitoring Networks. The HTLN serves 15 National Park Service units in eight midwestern states.

In 2009, HTLN provided the Ozark National Scenic Riverways with a two-person Exotic Plant Management Team (EPMT) to survey invasive exotic plants, to include rating abundance and distribution as well as ranking ecological impacts and feasibility of control, within the Big Spring Pines Natural Area and the Big Spring Natural Area. Ozark National Scenic Riverways is scheduled to receive another Exotic Plant Management Team in 2011, which will target additional high quality natural areas.

The Ozark National Scenic Riverways recognizes that prevention and early detection are the principal strategies for successful invasive exotic plant management. The information produced from this project will assist park natural resource managers in planning invasive exotic plant management strategies. For more information, visit the Ozark National Scenic Riverways Web site at http://www.nps.gov/ozar/index.htm or the HTLN Web site at http://science.nature.nps.gov/im/units/htln/.

— Kimberly Houf, Terrestrial Ecologist, Ozark National Scenic Riverways, 404 Watercress Drive, Van Buren, MO 63965, Kimberly_Houf@nps.gov, phone: 573-323-4941

Current Missouri Natural Areas Committee (MoNAC) Roster

MoNAC is the interagency organization charged with the inventory, identification, designation, and protection of Missouri's designated Natural Areas. MoNAC was formed in 1977.

MoNAC Members
Missouri Department of Natural Resources:
Dan Paige—Dan.Paige@dnr.mo.gov
Jane Lale—Jane.Lale@dnr.mo.gov
Ken McCarty, Co-chair—Ken.McCarty@dnr.mo.gov
Cheryl Seeger—Cheryl Seeger@dnr.mo.gov

Missouri Department of Conservation:
Gene Gardner, Chair (2010–2012)—Gene.Gardner@mdc.mo.gov
Lynn Barnickol—Lynn.Barnickol@mdc.mo.gov
Marlyn Miller—Marlyn.Miller@mdc.mo.gov
Mike Hubbard—Mike.Hubbard@mdc.mo.gov

The Nature Conservancy:
Doug Ladd—DLadd@tnc.org

Mark Twain National Forest:
Paul Nelson—pwnelson@fs.fed.us

Ozark National Scenic Riverways:
Victoria Grant—victoria_grant@nps.gov

Fish and Wildlife Service:
Paul McKenzie—Paul_McKenzie@fws.gov

Natural Area Coordinators
Missouri Department of Natural Resources:
Mike Currier—Mike.Currier@dnr.mo.gov
Missouri Department of Conservation:
Mike Leahy—Michael.Leahy@mdc.mo.gov

July 3 and August 7, 2010

Guided Wildflower Hikes at Prairie State Park, 10:00 a.m.

Prairie State Park is near Lamar, Mo. in Barton County. At nearly 4,000 acres, it is Missouri's largest publicly owned prairie. **Regal Tallgrass Prairie Natural Area** encompasses nearly the entire park.

August 1–5, 2010

North American Prairie Conference

The 22nd North American Prairie Conference will be held at the University of Northern Iowa. The conference organizers invite prairie professionals and enthusiasts to experience the Iowa prairies, the Cedar Falls metro area, University of Northern Iowa, and the Tallgrass Prairie Center. In keeping with the conference theme, "Restoring a National Treasure," there will be opportunities to observe prairie restorations and reconstructions. Participants will be able to discuss the latest prairie research, explore remnant and restored prairies on field trips, and view local and national exhibits. For more information and to register, visit http://www.northamericanprairieconference.org/.

August 13, 2010

Native Pollinators Workshop

Learn more about the importance of native plants, gardening for pollinators, native pollinator biology, and pollinator conservation practices at this workshop to be held in Columbia, Mo.

Speakers from federal, state, and non-governmental organizations will discuss the importance and biology of native pollinators in urban, rural, and natural areas. Participants will be introduced to native bee identification and learn how to create habitat using native plants. This workshop is also open to producers, farmers, extension and research specialists, Missouri Master Naturalists, conservationists, and others.

The event is organized by Lincoln University with the sponsorship of the Missouri Native Seed Association and collaboration with the Missouri Prairie Foundation, Missouri Department of Conservation, MU-Extension, the Xerces Society, Natural Resources Conservation Service, and the Farm Service Agency.

Registration: $15 per person will include lunch, native seed, and educational materials.

Time: 8:30 a.m. to 3 p.m., with option of a prairie tour from 3:00 to 5:00 p.m.

Location: MU-Bradford Research and Extension Center, Columbia, Missouri

For directions visit: http://aes.missouri.edu/bradford/

For registration or more information please contact Nadia Navarrete-Tindall (573-681-5392; navarrete-tindallr@lincolnu.edu) or Jennifer Hopwood (913-579-5241, jennifer@xerces.org) for more information and to register, or visit http://www.lincolnu.edu/pages/3081.asp.

August 27–28, 2010

Missouri Bird Conservation Initiative (MoBCI) Annual Conference

Theme: How does climate impact birds, and "weather" we can make a difference?

Days Inn, Columbia, Mo. For more information visit www.mobci.org or call Michelle McGrath (573-522-4115 ext. 3150).

September 17–19, 2010

Conservation Federation of Missouri Fall Conference

Camp Clover Point, Lake Ozark State Park. Focus of the conference will be Missouri State Parks. To register and for more information, visit www.confedmo.org or call 573-634-2322.

September 24–25, 2010

Prairie Jubilee at Prairie State Park

Preceding the Prairie Jubilee on the 25th will be overnight camping on the prairie the evening of September 24. Preregistration is required. At the Jubilee, enjoy guided hikes, cultural and natural history displays and activities, live music and food. 10:00 a.m. to 4:00 p.m.

To register for events and for more information, call the park at 417-843-6711 or send a message to prairie.state.park@dnr.mo.gov.

September 25, 2010

Prairie Day at Shaw Nature Reserve

This biennial event in Gray Summit, Mo., is co-sponsored by the reserve and the Missouri Department of Conservation. Hours are 10:00 a.m. to 4:00 p.m. There will be guided hikes through the reserve's 250-acre re-created tallgrass prairie, live music, pioneer crafts and games, bison burgers and more. For more information visit http://www.shawnature.org/events/prairieday.aspx or call 636-451-3512. While there, you can also visit the reserve's 146-acre **Shaw Bottomland Forest Natural Area.**

October 9–10, 2010

Cole Camp Prairie Day/Oktoberfest

Many prairie-related events will be happening in and around Cole Camp, Missouri, this weekend. Call 660-668-3810 for more information.

October 26–29th, 2010

37th Annual Natural Areas Conference Tan-Tar-A Resort, Osage Beach, Missouri

You are invited to the 37th annual Natural Areas Conference hosted by the Natural Areas Association (NAA), the University of Missouri-Columbia College of Agriculture, Food and Natural Resources, the Missouri Natural Areas Committee, and the National Association of Exotic Pest Plant Councils.

This year's conference will be held at the Tan-Tar-A Resort on the shores of beautiful Lake of the Ozarks in the Osage River Hills region of the Missouri Ozarks. Missouri's Ozark Highlands are home to some of the largest springs in the world, thousands of caves, the largest block of remaining forest and woodland in the central Midwest, and many endemic species. Within an hour's drive of Tan-Tar-A Resort are tallgrass prairies, glades, savannas, woodlands, forests, fens, caves, springs, Ozark streams, and the Missouri River. An extra effort has been made for this year's conference to have hands-on and in-depth workshop sessions paired with field trips to allow for training opportunities and continuing education credits. Please join us as we connect today's natural area managers with academicians and students, and young natural resource professionals with seasoned professionals from a variety of natural resource disciplines. To register, and for details, visit http://naturalarea.org/10conference/.

Conference Highlights

- Beautiful rural setting with outstanding natural features nearby
- Hands-on training workshops and associated field trips offering Continuing Education Credits
- Outstanding conference and pre-conference field trips to Missouri natural features that are some of the best remnant habitats in the Midwest
- Intriguing and thought-provoking paper sessions
- An innovative Natural Resource Connections Symposium linking resource professionals, academics and students across generations and disciplines.

Topics

- Natural Resource Connections Symposium
- Large River Natural Communities: Ecology and Management
- Caves and Karst: Ecology and Management
- Managing for Diverse Landscapes with Fire
- Glade and Woodland: Ecology and Management
- Tallgrass Prairie: Ecology and Management
- Stream Ecology and Conservation
- Plant Identification: Grasses and Composites of the Midwest
- Invasive Species: A Never-Ending Battle
- Reptile and Amphibian Ecology and Management
- Macrofungal Ecology and Identification
- Coordinated Weed Management
- Dendrochronology and Natural Areas: The Language of Tree Rings
- Pollinators in Natural Areas
- Conservation Easements and Natural Areas Protection
- GIS and Natural Areas Management
- Human Dimensions — Connecting Everyone to Nature
- Conservation Genetics

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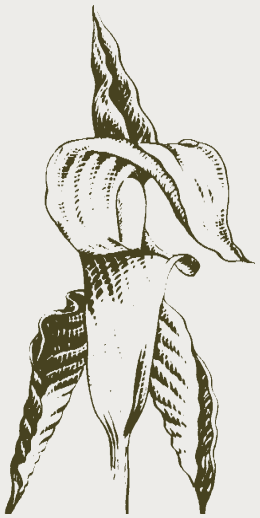

THE MISSOURI NATURAL AREAS PROGRAM BROCHURE is available for free to any citizen, organization, or business. Please help spread the word about Missouri's Natural Areas by distributing these brochures and making them available at offices, nature centers, outdoors-related businesses, and elsewhere. To order, contact Mike Leahy, Missouri Natural Areas Coordinator, Missouri Department of Conservation, P.O. Box 180, Jefferson City, MO, 65102-0180, michael.leahy@mdc.mo.gov, phone: 573-522-4115 ext. 3192.

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