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Reptiles and Amphibians in an Upland Longleaf Pine Forest

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Fire Science Brief

RESEARCH SUPPORTING SOUND DECISIONS

A scarlet snake (*Cemophora coccinea*) makes its way through a recently burned longleaf stand in the Oakmulgee District. Credit: Jimmy and Sierra Stiles, University of Alabama.

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Summary

Longleaf pine forests are prime real estate for the endangered Red-cockaded Woodpecker, which nests in cavities in older trees. While researchers and state and federal agencies carefully monitor and encourage the survival of this endangered species, beneath the canopy, a rich diversity of less mobile species abounds. Much attention has been focused on the use of prescribed fire to improve longleaf pine habitat for its own sake, and for the woodpecker. Very little is known about the effects of fire on the herpetofauna. In the Oakmulgee Ranger District of the Talladega National Forest in Alabama, scientists have measured the response of herps to fire within an 8,000-acre tract devoted to upland longleaf pine restoration. The goals of the study were to determine the effects of fire at different intervals and season of burn on the herpetofaunal community, and to devise a replicable tool to monitor ecosystem health and guide restoration efforts. While the structure of a longleaf pine savanna—the way the forest looks to the casual observer—is often cited as evidence of forest health, gauging ecosystem function can be refined by taking a closer look, at the community level, at these vertebrates, which are less mobile than any one species of bird or mammal, and which are a better indicator of overall forest health.

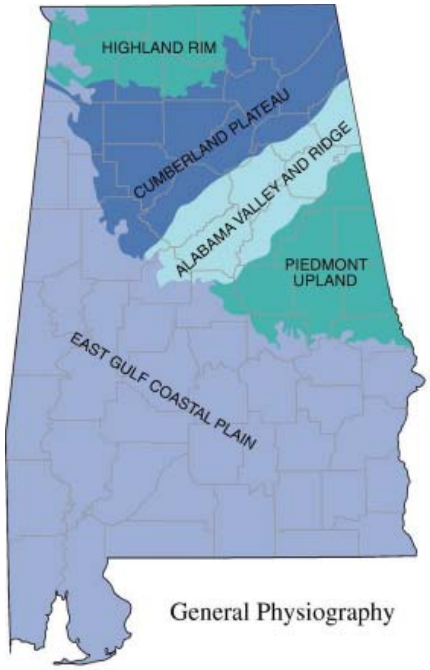
Key Findings

- Amphibians and reptiles as a community are better measures of overall ecological health of a system than any one species of vertebrate.
- The current management plan the Forest Service has adopted to restore upland longleaf pine in the Talladega National Forest includes judicious use of prescribed fire in a patchwork pattern and appears to do little long-term harm to reptilian and amphibian communities.
- In addition to time since the last burn, temperature variations at the small scale, or microclimate, the size of the stand, and proximity to hardwood stands have significant effects on community variability of the herpetofauna.
- Season of burn did not have significant adverse effects on reptiles and amphibians during the course of the study, though the sampling size was not large enough to draw firm conclusions.

Herpetofauna in upland longleaf pine

Longleaf pine (*Pinus palustris*) forests, which once occupied 90 million acres (36 million hectares) of the southeastern United States, are found today on only 3 million acres (1.2 million hectares), mostly scattered throughout the Atlantic and Gulf Coastal Plains. Prior to the extensive exploitation of this important timber species, however, its range extended further inland to the Appalachian physiographic provinces.

One small remnant of this ecosystem is found in the Talladega National Forest in west central Alabama, where the East Gulf Coastal Plain and the upland physiographic provinces—Valley and Ridge, and Piedmont—converge. The Fall Line, which extends along the eastern United States from southern New York to Alabama, marks a transition of varying width between the lowland Coastal Plains underlain by sandy soils, and the upland bedrock. The vegetation and wildlife also vary geographically and over time, along with soil conditions, elevation, weather patterns, and variations in climate.



The Fall Line separates the northern physiographic regions from the Coastal Plain. Credit: Department of Geography, University of Alabama.

"Some 65 million years ago, the oceans lapped at the shores as far inland as Tuscaloosa," says Leslie J. Rissler, an associate professor in the Department of Biological Sciences and curator of Amphibians and Reptiles at the University of Alabama. Changes in climate and sea level over the millennia caused terrestrial species to migrate inland and back again, but the successive waves of glaciation that scoured the more northern reaches of the continent during the Ice Age did not reach as far south as the Mobile Bay Drainage in Alabama, which includes the Talladega National Forest. For that reason, the species currently found there were isolated in separate and more southern glacial refugia from their northern kin, and they may have been spared significant extinctions from glaciations. The herpetofauna did, however, experience selective pressure in the upland forest, with its underlying bedrock and distinct vegetation. As a result, they differ from the herps found closer to the coast, both genetically and in their evolutionary adaptation to fire.

Topsy-turvy landscape

Of the 157,000 acres (63,540 hectares) that comprise the Oakmulgee Ranger district of the Talladega National Forest, 87,000 acres (35,000 hectares) harbor known nesting sites for the Red-cockaded Woodpecker. Within that area, 8,000 acres (3,250 hectares) are part of a 5-year Forest Service plan to remove unhealthy loblolly pine (*Pinus taeda*) and restore stands of native longleaf pine, using prescribed fire along with mechanical harvesting of loblolly pine. Part of the plan is to imitate the natural, patchy spatial pattern created by the historical fire regime.

The upland longleaf pine ecosystem is confined to the higher, drier ridges, while the mid-elevation and bottomlands are a mix of hardwood and pine. In some respects, it is a disconcerting landscape. Walter Smith, writing for *Forest Magazine* in 2008, observes that "the terrain…is hilly enough to conjure images of Appalachia. But on the ridgetops, the world is all coastal plain…the whole forest seems to have some sort of identity crisis, stuck indecisively between the mountains and the great river valleys of the south." The area is also a transition zone for reptiles and amphibians, and includes species characteristic of Appalachian hardwood forest and those found on the Coastal Plain. Smith is a doctoral student at the University of Alabama who worked with Rissler on a project, supported

by the Joint Fire Sciences Program (JFSP), to collect data on herpetofauna's response to fire and to conduct the first ever census of the herpetofauna along the Fall Line in Alabama. This is one of two studies in longleaf pine ecosystems of the upper Coastal Plain to measure response of herps to fire.

Why the herps?

Worldwide, the herpetofauna are in decline. Amphibians, which include salamanders, frogs and toads, and the legless caecilians, are at particular risk, with an estimated one third of the total species at risk of extinction. Amphibians are exquisitely sensitive to environmental insults, in part because most have skin that is permeable to water and air, and also because many have a biphasic life cycle; that is, they spend part of their life as aquatic residents and part of their life as terrestrial denizens.

The marbled salamander (*Ambystoma opacum*) breeds in fall in temporary ponds downslope from longleaf pine stands. Credit: Walter Smith.

Spotted Salamanders (*Ambystoma maculatum*) live in forested uplands for most of the year yet migrate to isolated wetlands for breeding each spring. Credit: Walter Smith.

The Oakmulgee District is a kaleidoscope of habitat types. These imposing black tupelo swamps lie scattered within a diverse matrix of longleaf pine and mixed hardwood forests. Credit: Jimmy and Sierra Stiles, University of Alabama.

In the tropics, disease has taken a harsh toll on amphibians. In the United States, the situation is less dire, but the presence of a fungal pathogen (*Batrachochytrium dendrobatidis*) in several states could prove deadly for many species. For now, California and Alabama are still rich in amphibian species. "Alabama is the number one hot spot in the country for amphibians," says Rissler. California and Alabama also lead the country in extinctions of amphibians. In California, the threats include habitat loss from development and expansion of invasive species. In Alabama, threats include hydroelectric projects, coal mining, and pollution that compromise the integrity of aquatic systems. For the herps that inhabit the rare, fire-dependent upland longleaf pine ecosystem, the absence of fire and expansion of hardwood forest are also threats.

Rissler and Smith have used a well established methodology for gathering census data on the herpetofauna in the Oakmulgee Ranger District. In addition, they have adapted a protocol, first used to monitor response of aquatic species to water pollution in the late 1980s, to measure the effects of prescribed fire on the herp community.

While the Red-cockaded Woodpecker is a prime target for protection under the Fish and Wildlife Service Recovery Plan, the woodpecker alone is not the best species to gauge overall ecological health of the forest. "Protection plans focus on woodpeckers, but amphibians and reptiles are a key group of organisms that should be better barometers of forest health," says Rissler. "Unlike birds, they can't disperse great distances, and they are ectothermic." That is, they have no internal means of regulating body temperature and rely on external environmental factors to stay warm or cool. In addition, because of their biphasic life cycle, they move nutrients from aquatic to terrestrial systems, and they feed on leaf litter and detrital invertebrates on the forest floor. "The decomposition of matter is directly affected by amphibians and reptiles, especially salamanders," says Rissler.

Community resilience

During the 3-year study, Rissler and Smith measured species presence, abundance, and diversity as they relate to time since last burn and season of burn. Twenty-two stands of 40 acres (16 hectacres) or greater of longleaf pine forest in a matrix of oak-hickory forest were selected. The choice of stands was carefully done in ArcGIS to control for distance to roads, water, and other features that could affect the results. In addition to 18 stands burned at 1-year, 4-year, and 7-year intervals, four stands that had not been burned for 20 years were established as a control. The stands were chosen to be similar in slope and elevation and in distance from permanent sources of water.

The team used standard herpetological methods to conduct the census. Y-shaped metal drift-fences funneled specimens into pitfall traps, buckets buried flush to the ground that collect specimens traveling along the forest floor. "The herps come across the fence and fall in the bucket," says Smith. Each bucket contained a wet sponge to prevent the animal from drying out. To capture arboreal

treefrogs, special traps similar to natural shelters were constructed of PVC pipe. Technicians also fanned out to look for specimens that were not on the move, but rather resting or burrowing under logs, stones, or leaf litter. Between January 2006 and July 2008, samples were collected for 14 days in a row, followed by 7 days of no sampling.

A prescribed burn overtakes a drift-fence at a study stand in the Oakmulgee District. Credit: Jimmy and Sierra Stiles, University of Alabama.

Each specimen was sexed, aged, weighed, and measured from snout to vent—the cloaca, which in herps is the end of the intestinal excretory and reproductive tracts—and length of tail. The animals were then toe-clipped to obtain tissue for later genetic analyses and released. For snakes, a piece of ventrical scute, one of the small scales on a snake's belly, was excised. If a marked specimen was found in further collections, it was excluded so that all analyses were based on real numbers, not recaptures. Specimens of tissue are being housed at the University of Alabama Herpetological Collection at the University of Alabama as part of a long-term effort to document the genetic diversity of herps in this unique physiographic zone. So far, more than 15 amphibian species and nearly 30 reptilian species have been identified, many of them quite common, such as the Spring Peeper often heard in vernal ponds and the Garter Snake, found in many suburban yards.

(Left) The Mountain Chorus Frog (*Pseudacris brachyphona*) is one of several species in the Oakmulgee District not commonly associated with longleaf pine forests elsewhere in the East. (Right) Skinks such as this broadhead skink (the largest skink in the southeast), are abundant residents of longleaf pine stands in the Oakmulgee District. Credit: Jimmy and Sierra Stiles, University of Alabama.

From these measurements, the researchers made several estimates: community biomass—the combined weight of all specimens—and species richness, diversity, and evenness. Species richness is the number of species within a stand. Species evenness is a measure of the relative number of species; for example, if five individuals are found in one sampling, with four individuals of one species and only one individual of another, the sample is uneven. "This is a holistic approach," says Smith, "looking at the broader community of herps rather than focusing on one species."

The Black Kingsnake (*Lampropeltis getula nigra*) is a subspecies found at the southernmost extent of its range in the Oakmulgee District. Credit: Jimmy and Sierra Stiles, University of Alabama.

The research team found that total species richness and abundance were not significantly affected in any of the stands no matter the time since last fire. They did find, however, that the relative abundance of each herp community is affected by fire. The numbers of each individual species within a stand change while the total number of species and animals does not. In addition, total biomass did not differ among treatment stands.

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They also weighed other variables that may be significant from the manager's viewpoint: the size of the stand, the microclimate as measured in temperature variations, which are affected by removing vegetation with fire, and the composition of the adjacent hardwood or hardwood/pine stands within a 1,640-foot (500-meter) buffer area. As they wrote in the final report to JFSP, "There was no 'ideal' burn interval found in our analyses, rather a dynamic mosaic of the herpetofaunal community that shifts across landscapes spatially and temporally with changes in burning, and is influenced locally by multiple variables from the entire landscape."

Rissler and Smith also used a smaller number of stands to assess the effects of season of burn, the dormant winter season, and the growing season. Most amphibians breed in spring and early summer, others breed in the fall, and managers are often concerned about the effect of season of burn on different species. In-depth knowledge of the habits of individual species and the vegetation they depend on, however, may not be as critical as the overall pattern of burns. "The management goal is not to burn the entire forest, but to create a random sequence in order to provide

habitat to species that react differently to fire," says Smith. "Diversity is the word."

Here comes the fire!

The strategies reptiles and amphibians use to survive fire remain poorly understood. Some may use burrows where they overwinter or breed. "Some can flee the fire if it is not too widespread," says Smith. Others, like the Eastern Box Turtle, dig into the earth and retreat into their carapace. "Live box turtles have been found with burn scars on their shells." Still others have the ability to detect heat from a distance and travel away from fire. Even the sound of fire may serve as a warning to some species. Researchers from Germany played the sound of fire to reed frogs, which would immediately seek shelter.

Many herpetofaunal species have evolved in an ecological context of fire, and some are dependent on fire for their existence. In the Gulf Coastal region, for example, some salamanders die off when fire is suppressed. "One species of salamander in the lower Coastal Plain relies on fire to scour depressions where they breed," says Smith. In the Oakmulgee study area, however, the herpetofauna are more typical of hardwood forests; no species known to be restricted to areas that commonly experience fire are found in the upland longleaf pine stands. "It's interesting and confusing."

A natural laboratory

The Oakmulgee Ranger District is potentially a natural laboratory and a living museum for reptiles and amphibians. Yet few people take advantage of the area. "When I go there I see tons of wildlife, but otherwise you hardly see a soul," says Smith. Those who do visit the forest are unlikely to spend much time exploring beneath logs or rocks on the forest floor. Moreover, many people have an aversion to the herps, especially the legless, slithering snakes. In an effort to raise awareness and appreciation of the herpetofauna of Alabama, Rissler and colleagues have established an outreach program, CAARE: Conservation of Alabama Amphibians and Reptiles through Education. Graduate students from the university bring visual aids and live specimens to local elementary, middle, and high school classrooms. "We keep salamanders, frogs, and snakes in our lab at the university," says Smith. "Some are locally common and can be found in people's backyards."

"One of the benefits of the JFSP grant is that we could hire technicians who lived nearby and could thus spend day after day checking the traps," says Smith. That type of labor-intensive monitoring is not always within the reach of land managers, however. In spring of 2009, researchers from the University of Alabama teamed up with volunteers from Auburn University and the University of Georgia to conduct a "bioblitz," spending two weekends to collect as many herps as possible. Teams from each school flipped logs, sifted through leaf litter, and used nets to check vernal pools for amphibian larvae.

Management Implications

- The Forest Service should continue its burn plan to mimic the natural complexity and variations in timing and area of burn, creating a patchwork of burn classes and ensuring diverse habitat for herpetofauna.
- The monitoring protocol developed in this study is replicable in other systems. Managers should consider the superiority of this approach over one that relies on monitoring a single species and/or more mobile species such as birds or mammals.
- The extensive monitoring that was conducted in the Talladega National Forest is labor intensive but could be reproducible, with some alterations, on a broad scale with the help of many volunteers trained by experienced herpetologists.
- Measuring community herpetofauna diversity, abundance, and biomass does not replace monitoring for the response of single species of special concern in restoration projects.

Vernal ponds provide essential breeding habitat for amphibian species that spend most of the year in forested uplands. Credit: Walter Smith.

"Reaching out to young students is key to inspiring the next generation of biologists and herp researchers," says Rissler. "In all our work, the project with the JFSP, in our laboratory, in schools, churches, and environmental organizations, the aim is to help local people understand how interesting and important biodiversity is to human and ecosystem health. If we can get our conclusions boiled down to something managers can use in their day-to-day work that benefits all of us."

Further Information: Publications and Web Resources

Species Inventory List. 2008. The University of Alabama/ Talladega NF Oakmulgee District, Longleaf Herpetofaunal Diversity, Talladega National Forest. http://bama.ua.edu/~firegrant/

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Scientist Profiles

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