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Burning and Bats: Fire's Effect on the Endangered Indiana Bat

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Fire Science Brief

RESEARCH SUPPORTING SOUND DECISIONS

The Indiana bat (*Myotis sodalis*). Credit: Rich Fields.

Burning and Bats: Fire's Effect on the Endangered Indiana Bat

Summary

The spring prescribed burn window in the Central Hardwoods is short (usually April) and good burning days are few. The Daniel Boone National Forest (DBNF) prescribed fire program is trying to regenerate oak ecosystems ahead of the arrival of gypsy moths in the region and the high overstory oak mortality that can result. If the burn window could be extended into the growing season (later spring), managers could control vegetation more effectively. However, the DBNF also serves as warm-season roosting habitat for the endangered Indiana bat, so burning into the growing season could potentially put the bats—and especially maternity colonies—at risk. Until now, no studies had been conducted regarding the risk to the bats from prescribed fire. Research was therefore needed to determine whether managers could burn later into the growing season without posing risk to the Indiana bat—and if so, how it should be done. The research shows that if bats are in torpor during a fire and cannot arouse quickly enough to escape, they may be harmed, and the risk of injury is directly related to fireline intensity. Fire's heat poses risk to the bats, but fire's gases do not. Models of bat ear burns showed that the height up to which ear injury is likely to occur corresponds roughly to the height up to which crown scorch occurs, and thus fireline intensities should be kept low enough so that crown scorch height does not approach the mean roosting height of 30 feet or 9 meters. The research suggests that risk to bats from prescribed fire can be greatly reduced through a combination of various approaches: (1) using ignition tactics that reduce fireline intensity, (2) choosing appropriate burn season/weather, (3) using ignition tactics that cue bats to arouse from torpor and flush, and (4) ensuring large roost snags (and trees that will become snags) are available. The research team also found that fire improves foraging conditions in the year following fire by increasing prey abundance.

Key Findings

- Bats that cannot escape fire may be at risk from heat but not gases.
- Modeling results show that bat ear burns occur up to heights similar to those at which crown scorch occurs, thus fireline intensities should be kept low enough to avoid scorch height that approaches mean roosting height (30 feet or 9 meters).
- Factors that mitigate risk to bats from fire include ignition tactics that reduce fireline intensity, choice of appropriate burn season/weather, ignition tactics that cue bats to arouse from torpor and flush, and ensuring large roost snags are available.
- Fire improves foraging conditions in the year following fire through its effects on insect prey abundance.

Opening the burn window

The number of good days for burning in the Central Hardwoods during the late winter and spring can be few. The weather is often wet and, as April turns into May, burning gets risky in terms of harming wildlife such as the Indiana bat, which is emerging from hibernation and migrating back to the area.

Spring prescribed fire on the Daniel Boone National Forest. Credit: Matthew Dickinson.

Managers on the Daniel Boone National Forest (DBNF) in Kentucky are facing a challenge: the gypsy moth is heading their way. Not a native insect, the gypsy moth has become one of the most notorious pests of hardwood trees in the eastern U.S. Since 1980, it has defoliated almost a million or more forested acres each year—and the DBNF has a lot of one of its favorite dishes: oaks. The DBNF prescribed fire program is trying to regenerate oak ecosystems and create the more open stands that characterized these ecosystems in the past ahead of the arrival of gypsy moths in the region and the high oak mortality that can result. If that narrow burn window could be extended into the growing season (later spring), managers could control vegetation more effectively—particularly species that compete with oak, such as maples, which are not fire tolerant. The study's lead scientist, Matthew Dickinson, sums it up: "It's not only about burn windows. It's also about fire effects."

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But this is Indiana bat country, and the species is listed as endangered. The current fall and spring burn windows overlap with periods when the bats are entering and leaving hibernation. So managers were concerned that burning risks disturbing or harming bats, particularly pregnant females that bunch together for warmth through the spring and early summer. No studies had previously been conducted regarding the direct risk to bats from prescribed fire. In fact, although many studies exist regarding fire's direct effects on vegetation, in general, effects on fauna have been given little attention. But with the looming arrival of the gypsy moth and the urgency to put more fire on the ground in the mixed-oak ecosystem, research into the subject became crucial.

This particular study used data from prescribed fires in southeastern Ohio and eastern Kentucky and models of carbon monoxide and heat effects. Collaborators included the Rochester Institute of Technology, Ohio University, Norris Consulting, and the Northern Research Station. The research was funded by the Joint Fire Science Program (JFSP) in 2005 and was completed in 2009.

Roosting male Indiana bat, Daniel Boone National Forest. Credit: James Kiser, USDA Forest Service.

About the bat

Although it ranges over a large part of the eastern U.S., the Indiana bat is so-called because the first specimen to be

described to science was one found in Indiana's Wyandotte Cave in 1904. Its scientific name, Myotis sodalis, means "mouse ear" plus "companion." As the name implies, they are very social creatures, clustering in large numbers during hibernation. The bats hibernate for six months out of the year in caves and mines referred to as hibernacula (yes, it does rhyme with Dracula). They have largely emerged from hibernation by the end of April, and then in the fall, they re-enter hibernation from September through November. Wooded areas make up their summer habitat, including upland mixed-oak forests. Females roost in maternity colonies of up to 100+ and give birth to only one pup per year. Indiana bats roost preferentially below loose bark on snags, but also roost under bark flaps that characterize old living white oaks and shag-bark hickories. Maternity colonies prefer large snags exposed to the sun, while males tend to roost in cooler microsites. Indiana bats use snags from a wide range of tree species—only a few species are unsuitable for roosting.

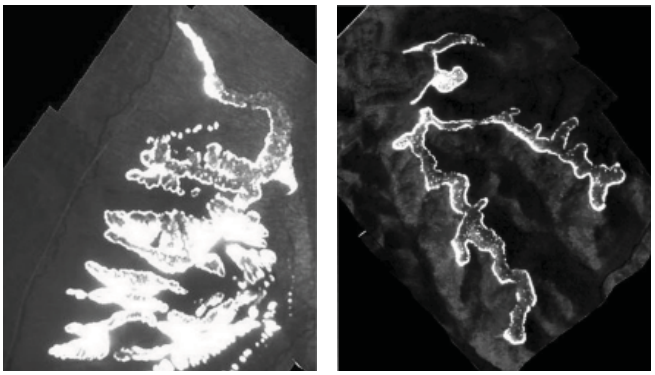
The Indiana bat was placed on the Endangered Species List in 1967 after winter populations had declined significantly at the majority of known hibernacula. Population trends in general have been upwards since 2001, although a new threat has surfaced. Mortality of Indiana bats from white nose syndrome has been confirmed in northeastern regions. The health crisis is killing a wide array of bat species, and scientists are working hard to understand the cause and find solutions. It may have been brought to the U.S. from Europe. It was first found in New York, then spread east, and then down the Appalachians. It's now poised to move west.

So, how *does* fire affect the Indiana bat?

When in warm-season habitat, the Indiana bat uses what's called *torpor*: a hibernation-like state in which body temperatures approach roost temperatures to conserve energy during the day. Time to arousal from torpor to a body temperature at which flight can occur can take minutes to tens of minutes—and this is where the big question comes in. If bats are in torpor during a prescribed surface fire and cannot arouse quickly enough to escape, will they be harmed by the fire's heat and gases?

On the one hand, burning later in the season reduces risk to bats because they are less likely to be deeply in torpor during warm weather (time-to-flight for a bat in torpor decreases exponentially as ambient temperature—and thus body temperature—rises), and they can thus more easily arouse and take flight. On the other hand, overstory canopy injury becomes more likely in warm weather burns of a given fireline intensity. The win-win situation is that, if you burn later in the season, torpor-related risk is reduced while, at the same time, managers may be able to achieve oak-ecosystem management objectives through multiple lower-intensity fires because maples and other oak competitors that are less fire-tolerant may be particularly vulnerable to fire after leaf flush. Growing season burning in the Central Hardwoods, however, has yet to be studied—so the risks and benefits remain largely unknown.

Back to the question of what happens if the bats don't escape the fire. The research team was surprised to discover that, according to standard toxicology models, fire's gases (especially carbon dioxide) are expected to have virtually no ill effects on the Indiana bat except directly above flames in the most intense fires. The study does suggest, however, that heat effects would harm bats well before the gases would. The research team chose to model bat ear burns as the factor determining risk of injury. Bat ears are the most vulnerable part of their body for two main reasons. First, they're oriented down due to their roosting posture and, more importantly, they're nearly hairless. Fur is surprisingly effective at insulating the bat's body from heat, but the exposed ears are highly susceptible to injury. Models of bat ear burns showed that the height at which ear injury is likely to occur corresponds generally to the height at which crown scorch occurs. Indiana bats roost at an average height of approximately 30 feet (9 meters); therefore, managers should focus on keeping fireline intensities low enough to avoid scorch heights that approach this mean roosting height. Dickinson explains: "It's a good rule of thumb. Managers have a good sense of the height at which crown scorch will occur in a given fire, and that's the height at which you'd be putting bats at risk."



Variation in prescribed fire behavior created by different ignition tactics. (Left) Ignition by helicopter over a ridge and down-slope producing a mix of backing, heading, and flanking fire. (Right) Ridge ignition leading to primarily backing fire that extinguishes on lower slopes.

It's in the way that you use it

So what's the solution to the DBNF managers' challenge? The happy news is that risk to bats from prescribed fire can be greatly reduced through a combination of various approaches: (1) using ignition tactics that reduce fireline intensity, (2) choosing appropriate burn season/weather, (3) using ignition tactics that cue bats to arouse from torpor and flush, and (4) ensuring large roost snags are available.

Reducing fireline intensities and thus flame height mitigates risk to bats because the critical plume temperature at which bats could be injured (approximately 140°F or 60°C) does not reach roosting height. Burning in breezy conditions can also lessen the effects of fire's heat. Furthermore, tactics such as ridge ignition, commonly used on the DBNF, result in backing fires that predominantly

spread downhill at low intensities and self-extinguish on middle and lower slopes. In addition to keeping prescribed burns to lower intensities, ridge ignitions specifically target the drier areas on landscapes where oaks tend to occur, leaving wetter areas unburned.

Indiana bat maternity roost. Credit: James Kiser, USDA Forest Service.

Determining the right burn season/burn weather brings us back to the bats' use of torpor and the fact that, in warmer temperatures, bats arouse from torpor more quickly. There are data showing that the eastern red bat—a bat that hibernates for multi-day periods in leaf litter during cold snaps—flushes from the litter soon after ignition when temperatures are warm. And field data collected while radio tracking four tree-roosting northern long-eared bats during a prescribed fire conducted on a warm day suggests that bats move readily. Two of the bats were tracked continuously during the ignition period, and they flushed within 101 minutes of nearby firing operations. All four of the bats located by radio-tracking had changed roosts during the burning period. These data indicate that extending the burn window later into the spring can actually help to protect the bats.

In addition to burning during warmer ambient temperatures, managers can help ensure bats wake from torpor more quickly through ignition operations that proceed slowly at first so that smoke is transported over the burn unit before the main ignition operations begin. Eastern red bats have been shown to use both the sound and smell of fires as cues for arousal. Information on arousal cues and times for eastern red bats provides useful insight, but confirmation is required for other species, such as the Indiana bat.

Lastly, risk to bats can be reduced by ensuring ample large snags are available for roosting. In addition to providing ample room for maternity colonies, the larger the snag, the higher up the bats can roost, allowing for a safer height above the critical plume temperature at which injury can occur. Forest practices should therefore focus on leaving a proportion of large trees on the landscape that will eventually become large snags for roosting. Research shows that bats choose to roost in larger than average trees from the pool of suitable snags, and we can therefore conclude that allowing more trees to become large on landscapes in which tree-roosting bats live would reduce bats risk from fire and generally improve maternity habitat. But again, more research is needed.

Fire and food: Upping the bounty

The use of fire is generally advocated as a way of improving bat habitat—through snag production for roosting, the creation of more open stands for better foraging, and increased insect abundance and diversity. Field data collected by the research team supports this latter phenomenon. The team found that fire does indeed improve foraging conditions in the long-term by increasing prey quantity in the form of insects attracted to post-fire dead wood. The diet of the Indiana bat consists primarily of moths and beetles, and a study on female northern bats in which these insects were captured in blacklight traps both pre- and post-fire showed that captures of moths did not change, but captures of beetles actually increased.

Taking it further

Because this study of fire's direct effects on the endangered Indiana bat is the first of its kind, much more research is needed. First, torpor dynamics of bats during burning season and their response to fire needs to be further studied. The key areas include (1) cues that initiate arousal, (2) the time required for flight after arousal, and (3) gender differences in torpor behavior (specifically, how often females use torpor during the spring and fall burning seasons). Dickinson spells it out: "We want to get more transmittered bats in fires, which we've been able to do once. We want to know what they're doing during burns, particularly when the weather is cool."

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A second area that needs to be looked into further concerns forestry practices that leave large trees and snags on the landscape. We know that female bats prefer to roost in large, warm snags—large because there's enough room for the entire maternity colony (with the side benefit of being higher up away from potential fire) and warm

to conserve energy. Both a snag's size and location can influence its temperature. If it's large enough to rise above the surrounding canopy and/or is located on a south-facing slope, it will be more exposed to solar radiation. So scientists need to consider whether large trees need to be left only in certain parts of the landscape to protect bat habitat and how many are needed. We need to better understand how fire can be used over the long-term and over landscapes to manage snag populations. This topic is currently being researched in the southern Appalachians, funded by the JFSP.

Third, further study must be conducted on the seasonality of habitat use and the effects of fire. Which parts of the landscape are bats using and when? What constitutes high-quality foraging habitat? We need to find answers to these questions because when bats are entering hibernation, they need to put on weight quickly, and when they emerge from hibernation, they have very low energy reserves. Maintaining high-quality foraging habitat near hibernacula therefore becomes greatly important. Moreover, protecting and improving the critical foraging habitat near hibernacula may help to alleviate the high mortality rates resulting from white-nose syndrome by helping those that do live to survive.

Ridge ignition on the Daniel Boone National Forest. Credit: Jake Royce.

Fourth, plume models need to be better validated before they can be used to set quantitative guidelines on fireline intensities. The rule of thumb is that scorch height is similar to the height of bat ear injury, but predicting that height from fire behavior is still uncertain. Also, fire managers know that burning on hot days can result in overstory injury. Studies under consideration would test the hypothesis that oak competitors could be more readily killed from lower intensity fire as spring progresses. As such, burning later and at lower intensities may be a way to reduce bat risk while more efficiently accomplishing vegetation management. Data will show. But then, species other than the Indiana bat need to be considered. Does burning later in the spring potentially harm other wildlife species such as reptiles and ground-nesting birds? If so, how much? And do potential habitat improvements outweigh the risk from the direct effects of fire?

So yes, there's much work to be done and many questions to be answered. But the research conducted thus far shows promising signs that restoring the mixed-oak ecosystem through the use of fire—with appropriate precautionary measures—can indeed be accomplished in harmony with protecting the endangered Indiana bat. When asked about the main message for managers, Dr. Dickinson cautioned, "It's pretty straightforward. Be careful until we know more…and take the mitigating steps that you can to reduce risk to bats."

Management Implications

- Reduce fireline intensities and burn in breezy conditions to mitigate risk to bats from heat effects.
- Extending lower intensity burning later in the spring may both help achieve ecosystem management objectives and reduce risk to bats because they arouse from torpor more quickly in warmer ambient temperatures.
- Proceeding slowly during the early phase of ignition provides cues to bats that fire is on the landscape and allows them to arouse from torpor and flush.
- Large snags and trees should be left on the landscape to provide ample maternity roosting habitat for current and future use as well as potentially reduce risk from fires.
- Evidence is emerging that prescribed fire can improve bat habitat.

"It's pretty straightforward. Be careful until we know more…and take the mitigating steps that you can to reduce risk to bats."

Further Information: Publications and Web Resources

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Scientist Profile

Matthew Dickinson is a Research Ecologist with the USDA Forest Service, Northern Research Station. His work focuses on the biophysical processes that link the behavior of fires with their effects on vegetation and fauna. He received his PhD from Florida State in 1997 for work on tropical forest dynamics after logging and natural disturbance and conducted post-doctoral work on boreal fires at the University of Calgary.

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