Joint Fire Science Program

Fire Science Brief

RESEARCH SUPPORTING SOUND DECISIONS

Prescribed fire used in a red pine stand, Seney National Wildlife Refuge in the eastern Upper Peninsula of Michigan. Credit: Greg Corace.

Fire History Study Reveals Surprises about Mixed-pine Ecology in Eastern Upper Michigan

Summary

Mixed red and white pine forests in eastern Upper Michigan saw frequent fires, about every 50–60 years, before Euro-American settlement. Post-settlement, the fire cycle has lengthened and forest composition has shifted to include more jack pine and fire-sensitive deciduous trees, increasing fuel loadings and changing wildlife habitat along the way. In cooperation with researchers and land managers at Seney National Wildlife Refuge, researchers at The Ohio State University are working out details of combining mechanical treatments with prescribed fire to restore mixed-pine forests dominated by red and white pine. In particular, their findings about red pine ecology could change the way these forests are managed and restored. The researchers advocate mechanical fuels reduction in conjunction with broader ecosystem-based management objectives, such as restoring ecosystem integrity. The researchers will integrate these findings into an adaptive decision support tool to be used in the development of restoration-based fuel reduction recommendations.

Key Findings

- Fire plays an important role as a disturbance in mixed-pine forest ecosystems at Seney National Wildlife Refuge and in the eastern Upper Peninsula of Michigan.
- Fire outside of the natural range of variation results in contrasting stand structures and compositions relative to those occurring following fires within the natural range of variation.
- Wildfires in these landscapes were not historically stand-replacing events.
- Mature red pine will respond to release from competition following wildfire.

A changing landscape

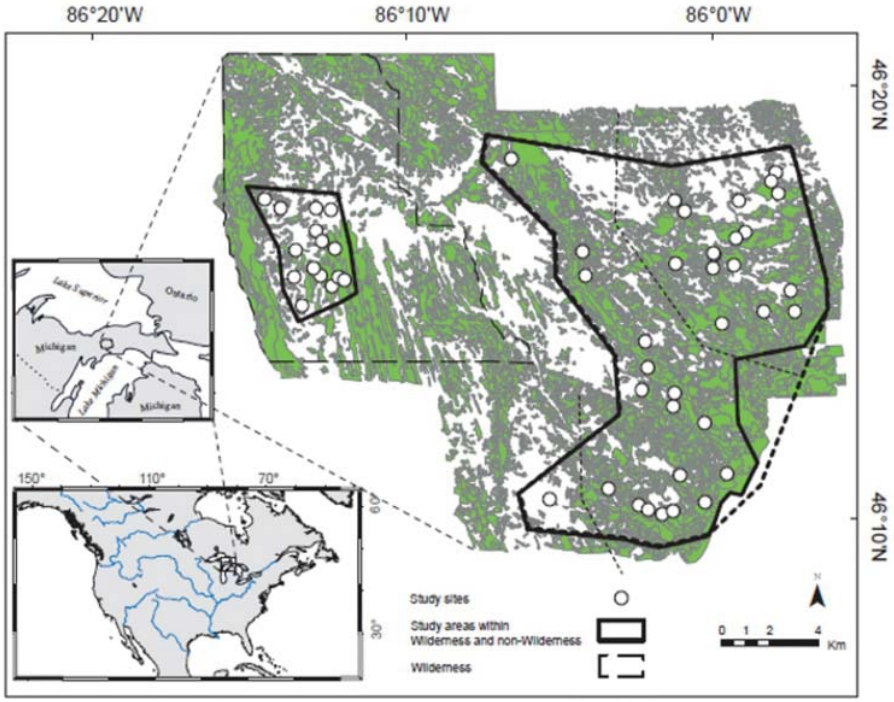
Forest scientists may have thought they understood the ecology of mixed-pine forests in eastern Upper Michigan, but this research revealed several surprises that may alter the long-term management of these ecosystems.

As described in the Joint Fire Science Program's (JFSP's) final report, Seney National Wildlife Refuge (NWR) in the eastern Upper Peninsula of Michigan includes "glacial outwash channels and a matrix of patterned fens interspersed by sand ridges." Red pine forest ecosystems historically dominated Seney NWR, with eastern white pine and jack pine also present. Now the landscape contains more jack pine and fire-sensitive species, including American beech, sugar maple, and red maple, along with other coniferous species.

"We examined in this landscape three major time periods that have shaped these mixed-pine systems in the eastern part of the Upper Peninsula," says Charles Goebel, associate professor in the School of Environment and Natural Resources at The Ohio State University. "You had pre-Euro-American settlement," he continues, "which we defined as prior to 1860. Then from about 1860 to 1935, you have a utilization period, during which you had a lot of Euro-American settlement going on, along with exploitation of the forest resources." Then there were lots of slash fires, followed by attempts to convert the land to agriculture, which typically failed. Many of these parcels were abandoned and reverted back first to the state and then the federal government.

Great gray owl in red pine stand, Seney NWR. Credit: Greg Corace.

In 1935 Seney NWR (94,245 acres) was established, with a primary emphasis on managing the landscape for migratory waterfowl. Over time, the management emphasis shifted first to other wildlife species, such as neotropical migratory birds and other nongame wildlife, and now includes the maintenance and restoration of natural ecological patterns and processes.



Wilderness and non-wilderness portions of Seney NWR with stand locations (open circles). White areas on the refuge map indicate marshland areas, and darker areas indicate forest vegetation. Broken lines in the lower central part and in the upper right part of the Seney map delineate the outwash channel (lower part) and sand ridge (upper) landforms of non-wilderness area. Credit: Charles Goebel.

Understanding the historical legacy of fire

"We were interested in understanding the historical legacy of fire in the mixed-pine forest ecosystems of this region. We wanted to better understand the basic characteristics, the seasonality, the fire return interval, how Euro-American settlement influenced the natural fire characteristics, and how that then influenced the structure and composition of the forest ecosystems over time."

This project represents an ideal situation for applied research, as one of the principal investigators, Greg Corace, is the forester and ecologist at Seney. He identified these questions as critical to successful management at the refuge, and was instrumental in the execution of the field study and interpretation of the results.

Goebel's crew used wedges from live and dead trees to determine the fire history of the landscape, and quantified the role of fire history on forest structure and fuel loadings on 85 plots at Seney NWR, some with long histories of human disturbance and others old growth. The virgin stands in the Seney Wilderness Area and the Strangmoor Bog National Natural Landmark contained some of the best remaining old-growth mixed red and white pine forest ecosystems in the Upper Lake States. "These areas are multi-cohort [multi-aged] stands," Goebel says, and "fire really hasn't been excluded in those sites. It's been allowed to burn naturally, because it is a federally designated wilderness area in the refuge."

The study also involved interviewing 13 land managers from the U.S. Fish and Wildlife Service (5), the Forest Service (3), The Nature Conservancy (3), and Michigan Department of Natural Resources (2) about mixed-pine forest management on lands under their jurisdiction. Each of the managers has discretion to implement land management practices that affect ecosystem composition and structure. The goal was to determine the managers' attitudes toward and use of fire by the major federal partners of the JFSP who are managing mixed-pine forests in this area.

"Ultimately," says Goebel, "we know that fire is important to the regeneration of these species and to creating the kinds of structures that we observe in old-growth forest ecosystems across the region. These forests look a lot different structurally than what's there now, where fire has been excluded for 80 years or more."

Fire can play an important role in "ecological forestry," which is being practiced at Seney and other NWRs. "Ecological forestry," Corace and Goebel write in a recent article in *The Wildlife Professional*, "does not attempt to maximize the productivity of any single commodity, amenity, or species. Instead, it allows for multiple goals—improved wildlife habitat, carbon sequestration, soil stabilization, water filtration, and economic gain—thus enabling forest conservation and restoration across various ecosystem and ownership types."

Low-intensity stand-maintenance fires were key

Understanding the ecology is critical to understanding how to implement fuel treatments and to manage the refuge overall. "We found that historically fires in these landscapes were not stand-replacing," Goebel explains. "These systems were maintained by low-intensity fires or maintenance fires that created stand structures that are much different than what we have now. Maintenance fires really drive the structure of these multi-cohort stands."

The research revealed that before European settlement low-severity fires burned about 12,000 to 25,000 acres in this area every 50 to 60 years, which was more frequent than expected. Forest management since settlement has lengthened that natural fire return interval, increasing fuel loads and shifting forest composition away from mixed pines toward maple and aspen species. Stands that had been harvested were clearly distinguishable from virgin stands by having a greater abundance of jack pine and lower structural diversity of both the overstory and understory.

Dense jack pine stand (left) that has developed on a former mixed-pine site contrasted with an old-growth mixed-pine stand (right) that has experienced frequent low-intensity surface fires. Credit: Charles Goebel.

If a fire did start in many of these areas today, it might be stand-replacing. Around the turn of the 20th century the forests were high-graded, leaving large swaths of essentially single-aged trees. The fuel loadings are currently at potentially dangerous levels. Pre-settlement stem densities were roughly 120 trees per acre; now they are roughly double that. Therefore, low-severity prescribed fire treatment will be almost impossible in human-impacted forests.

In their final project report the authors state, "Because of the important conservation status of these ecosystems and the highly altered conditions, these forest ecosystems are high priorities for restoration." However, the various landforms at Seney NWR have different fire cycles and forest compositions and structures, so the team investigated those differences in more depth so they could develop fuels management recommendations for all of them.

Landforms influence fire history and forest composition and structure

Tree-ring analysis showed that the glacial outwash channels and sand ridges at Seney historically burned on average every 53 years and 47 years, respectively. Many of these fires were small and relatively isolated, but larger landscape-scale fires occurred about every 160 years for mixed forests of jack, white, and red pine, versus about every 320 years for eastern white pine- and red pine-dominated tracts. These larger fires also appear to have been strongly associated with large-scale regional and continental climatic patterns.

"One of our key questions was trying to understand how fire and fire history differed between two different landforms that dominate this glacial landscape," Goebel explains. "We have embedded sand ridges that are aeolian [wind-blown] glacial deposits. In eastern Upper Michigan, these ridges of maybe a hundred meters across by a couple hundred meters to a thousand meters long are surrounded by wetlands and are not connected. Tree ring analysis showed when a widespread drought had occurred. Only during these times the intervening fens would dry out and burn and the sand ridges would essentially become connected for short periods.

Sand ridge landforms embedded in the wetland matrix at Seney, NWR. Credit: Charles Goebel.

The other landform of special concern was outwash channels. These are very sandy areas that occur along streams and rivers. They were channels underneath the glaciers 10,000 years ago. They tend to be linear, narrow, and more connected than sand ridges. Tree ring analysis revealed that fires greater than 100 hectares in this landform resulted from widespread drought as described above.

Goebel says, "These large fires really helped drive the regeneration, or at least the recruitment, of red pine into the overstory in these multi-cohort old growth reference ecosystems." This study showed that many of these trees got their start after fires that were recorded in a single year across all of the sand ridges disbursed within this large wetland complex.

Surprises about red pine ecology

Another key finding is that both red and white pine, which tend to be classified as shade-intolerant to shade mid-tolerant species, do respond to release from shade, even after being suppressed for more than 100 years.

Goebel notes, "A lot of us were taught that red pine does not respond well to release; thus, there's a specific management guide for dealing with red pine in the Lake States." But the findings of this research "really suggest to me that red pine will respond to release under the right conditions," Goebel says that it is not so shade intolerant as once thought. "So there is potential to move away from traditional red pine plantation management in the Lake States," he continues.

"To see individuals that were no more than 2 or 3 inches in diameter that were 150–200 years old that after a major fire had sustained release and sustained growth for a period of 25–30 years was just a big surprise to me," Goebel acknowledges. "So that suggests that we could look at restoring a lot of these Civilian Conservation Corps-era pine plantations that were planted across the Lake States through some sort of thinning or variable retention harvest that opens up these stands to the point where those individuals will respond to a release." The goal with these harvests would be to reduce basal area by about 70 percent.

Harvest in a fuel reduction and structural restoration treatment at Seney, NWR. Credit: Greg Corace.

Attitudes about fire as a tool

Goebel foresees mechanical treatments being used here more than prescribed fire for restoration, even though more than 75 percent of respondents agreed that fires are a critical ecosystem disturbance in these forests.

The interviews revealed that in the eastern Upper Peninsula of Michigan, managers are instituting fuel treatments less to reduce fuels for fire prevention than to restore wildlife habitat and/or ecosystems. Ecologically motivated objectives, such as restoring ecosystem integrity, were more important to managers than socioeconomic objectives, such as providing forest products. However, the reverse was true for fire management.

Protecting public safety took precedence over ecological objectives. More than 75 percent of respondents said that they were concerned about risks to human health and life, timber products, and property. Although they were often interested in using fire as an ecosystem management tool, they felt limited by uncertainty about risks and the legal ramifications in case something went wrong. They also had to balance the desire to achieve short- versus long-term objectives, and other barriers, such as institutional mandates.

Developing decision support tools

Goebel and colleagues want to design and implement restoration plans that integrate fire back into the systems, or at least fire-surrogate practices, whether mechanical removal or thinning operations. Managers need to recognize that it may take a combination of mechanical removal and prescribed fire to restore the structure and composition of these mixed-pine systems. The team is now designing some demonstration sites and implementing experiments where they can perform different types of silvicultural mechanical treatments. The goal is to design techniques that will emulate the effects of a maintenance fire—a moderate-intensity fire that would essentially thin from below, creating some large gaps in the forest. Through these

maintenance fires, they would hope to simulate the multi-cohort structure of the old growth forests in the area.

"Part of what we're doing," Goebel says, "is developing the decision support tool that will help managers say, 'I know I'm concerned about x, y and z; what options will help me meet certain objectives, whether those objectives involve wildlife management or fuels treatment or ecosystem restoration, while still addressing those concerns?' This will help managers use the information that we've gained."

"Our message," Goebel notes, "is that the importance of fire in regulating the structure and function of these systems has changed. There's a greater awareness of the importance of fire in these systems, and that's going to be critical when we think about restoring mixed-pine forest ecosystems that haven't been heavily exploited across the northern Lake States."

No shortage of ideas for the future

This research has led to a slew of ideas for further research. The team will continue to work toward the goal of producing on-the-ground recommendations for using forest treatments to emulate the types of forest structures that occurred following a natural wildfire in the pre-Euro-American landscape. "We want to understand more about how specific silvicultural treatments and combinations of treatments—different types of harvesting regimes, thinning operations, either in combination with or prescribed fire alone—emulate those legacies of natural disturbance," says Goebel. The research team, through another JFSP-funded project, is developing a fuels treatment guide for mixed-pine forests of the northern Lake States.

They also want to understand more about the basic life requirements of red pine. "How open do these stands need to be?" Goebel asks. "How heterogeneous can they be? Do we need to look toward creating large gaps that emulate the structure that occurs following some of these larger fires that we've documented over the years that have produced pulses of red pine regeneration in these old-growth systems at Seney? How big do the gaps have to be?"

Goebel and his colleagues also want to quantify the success of various restoration-based fuel reduction techniques; to repeat the forest history research described here for other types of fire-dependent systems (e.g., jack pine, black spruce peatlands, and coastal pine forests) in the area; and to look at fire's role as a disturbance agent in red pine-dominated forests across its native range.

The integral partnership with Seney managers in this project dovetails nicely with the team's work in leading one of eight JFSP-funded fire science consortia around the country, theirs for the Lake States (Michigan, Wisconsin, and Minnesota). "Essentially what we're trying to do," Goebel states, "is act as a liaison and as an exchange between resource managers and scientists across the region. Often managers are asked to or mandated to use the best available science, but they say 'We don't know what that is.'" The consortia will help ensure that there's an exchange of information between managers on the ground, scientists in the region, policymakers, and the national office of JFSP.

Management Implications

- The research team and managers at Seney are working cooperatively to design mechanical treatments and prescribed fire plans that emulate the effects of the pre-Euro-American fire regime.
- Following thinning of dense jack pine in the eastern Upper Peninsula of Michigan, planting red pine or leaving mature red pines as seed trees may be reasonable techniques for red pine restoration.
- Fuels reduction or management should be done in conjunction with ecosystem-based management objectives, such as improving wildlife habitat. Managers need decision-support tools to help weigh competing objectives and tradeoffs.

Further Information: Publications and Web Resources

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