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Low-intensity Fire in Eastern White Pine A Supporting Role in Understory Diversity

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Joint Fire Science Program

Fire Science Brief

RESEARCH SUPPORTING SOUND DECISIONS

Northern forests with an eastern white pine component. Credit: Aniszewski at Dreamstime.com.

Low-intensity Fire in Eastern White Pine
A Supporting Role in Understory Diversity

Summary

Although high-intensity fire has been studied extensively in the forests of the Great Lakes region, the role of low-intensity fire in stands of eastern white pine has received almost no study. For this project, scientists and mangers teamed up in northern Wisconsin to find out what low-intensity fire means for white pine regeneration and fuels reduction. Surprisingly, there was no white pine regeneration in the burn units even five years after fire. But low-intensity prescribed fire triggered a very strong understory response in terms of cover and richness, and can likely be used to support a wide variety of management objectives. It's also likely that moderate-intensity prescribed fire can be used safely to reduce fuels in these northern ecosystems that have a white pine component.

Key Findings

- Diversity and cover of both early and late growing season understory communities responded very strongly to low-intensity prescribed fire.
- Low-intensity prescribed fire did not stimulate regeneration of white pine.
- Low-intensity fire reduced litter layer by only 50 percent, measured by weight.
- Sapling mortality in burned units was much more significant in the second post-treatment year.
- The mechanical treatment of anchor chain dragging increased surface fuels.

Knowledge gap for low-intensity fire

The eastern white pine is the tallest native conifer in the upper Midwest. During colonial times, the mighty trunks were prized as masts for the Great Lakes sailing ships that enabled regional settlement and commerce on a large scale. Logging during the 1800s drastically reduced white pine numbers leaving few seed trees in some areas. Subsequent fires consumed many of the remaining seedlings and saplings.

By the 1930s, fire was largely excluded from what remained of Great Lakes forests. The Eastern white pine has struggled to recover in many areas, especially where soils are relatively moist. The species still dominates however in drier pine forests, and can be found scattered throughout the understory in mixed hardwood communities. Forests with an Eastern white pine component aren't widely known for their wildfires in this day and age, but the role of fire in Great Lakes forests where these evergreens grow has been studied for decades. The moderately fire resistant species is considered fire adapted because it evolved with documented fire occurrence patterns. It slowly decreases in number over time when fire is excluded from the landscape. The fire regime varies depending on site moisture and overall vegetation community. It's known that prior to European settlement fires burned with varying intensity at varying intervals across the region. High-intensity, stand-replacing fires burned every 150–300 years on average, supporting white pine regeneration by reducing competition and increasing sunlight where mature survivors seeded new stands.

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During the centuries between extreme events, low to moderate-intensity surface fires peppered sections of forests every 5–50 years. Unlike the stand-replacing fires, the role of these fires in this ecosystem has received very limited study. To remedy the situation, forestry professor James Cook of the University of Wisconsin at Stevens Point teamed with Wisconsin's Menominee Tribe and the Joint Fire Science Program to spearhead needed inquiry into this low profile ingredient of the white pine/fire equation.

Managers with the Menominee Tribe had questions about using prescribed fire to prepare seeds beds for planting and to reduce competition for white pine seedlings in tribal forests. The tribe had experimented with low-intensity prescribed fire but their efforts resulted in significant loss of mature seed trees. In addition, the tribe had achieved some success at fuel reduction using herbicide in late summer and following it with mechanical treatment (a large anchor chain pulled by a bulldozer) a month later. But results weren't sufficient from a management perspective, especially in moist sites with a white pine component.

Cook wanted to compare how prescribed fire fared relative to this treatment, and to investigate the cause of the unexpected mortality of mature pines from previous attempts at prescribed burning. He was also eager to investigate his own questions about fire ecology in the system, and to support the tribe's desire to naturally regenerate white pine. Natural regeneration made sense not just from a timber management standpoint, but from Cook's ecological restoration and biodiversity perspective. The paths to answers naturally converged and the team crafted the study to serve the needs of everyone involved.

"I wanted to know more about what happens between these high-intensity events that may not occur for 200 years or more," Cook says. "What is the role of low-intensity wildfire in ecosystems with a significant component of Eastern white pine? How should fire be implemented in this system to help manage an important forest resource? I wanted to flesh out the fire ecology picture and expand our knowledge beyond the already well studied high-intensity events."

Prescribed fire in the treatment mix

The Menominee Forest of northeastern Wisconsin supports some of the oldest white pine communities in the Great Lakes region. Two stands of managed, even-aged, 140-year-old white pines were chosen as study sites. White pine was the dominant mature species in all the treatment units; but there was a small-to-modest broadleaved component. The seedling population was dominated by red or sugar maples. Twelve years before the study, the overstory was thinned by thirty to forty percent, and the slash left in place. A dense intermediate layer of hardwood saplings had developed which included maple, birch, and cherry.

The study took place on forests managed by the Menominee Indian Tribe of Wisconsin.

The original proposal called for three treatments and a control, but one of the prescribed fire treatments (mechanical + backing fire) was shelved. They never got the burning window they needed in 2002 or 2003, and conditions weren't dry enough to get a backing fire to burn readily through the relatively moist forests of the study sites. There was a positive side to this change in plans however, as it gave them an additional year of pre-treatment data and a broader, deeper foundation from which to evaluate the treatments. They used this opportunity to evaluate the density and composition of the seed bank, and to perform a detailed analysis of the early growing season understory layer.

They ultimately implemented two treatments: an herbicide treatment late in August of 2002 followed a month later by mechanical treatment, and prescribed fires implemented in late April 2003, before leaf-out.

To address the matter of tree mortality from previous prescribed fires, Cook 'nested' litter removal treatments within the burns. Litter was raked away from randomly selected overstory white pines to measure the amount of heat generated by the litter layer and to assess the suitability of fuel removal as a means to protect residual seed trees. Litter temperatures were measured with heat sensitive paint applied to clay tiles. Observers recorded flame heights while the burns were in progress.

Five years later—No white pine regeneration

"None of the treatments resulted in white pine regeneration, which is undesirable from the tribe's standpoint, but I'm more neutral," Cook says. "I was curious to see if seeds were coming down and whether burning would facilitate their establishment from an ecological perspective, but it didn't. We can't be 100 percent sure that it wouldn't have though had there been a large seed crop that year. But we didn't document whether seed fall was limited or abundant."

Cook also notes the long life span of white pine, and how a preliminary study like this can't take in the whole picture. "Most white pine can easily live 250 years and some have lived as long as 600 years," he explains. "How frequently would a community of white pine need to regenerate in order to maintain itself on a site? It's not even going to start producing seed until it's forty or fifty years old under normal conditions, so it doesn't have to establish a large crop of seedlings every time one of these low intensity fires occurs in order to perpetuate itself. There are going to be six to eight of these fires within the lifespan of one generation because of the longevity of the species."

"There may be no reseeding at all in response to low-intensity fires in these mesic sites, as long as there is still a component of high-intensity fire in the regime," he continues. "Maybe these low-intensity fires were important ecologically for other reasons, but not for the purpose of maintaining the white pine. That's not proven by any means but it's a stronger hypothesis in terms of how the system maintained itself because of the level of competition."

Prescribed fire burns at the base of a mature white pine.

Burning hotter a safe option

The low-intensity prescribed burns in the study did not cause any overstory mortality, nor did they increase invasive exotic plants. Cook thinks that the limited stimulation of exotics may have been related to the fact that there were very few exotics to begin with in the study sites compared to state or private land in the region. "In all likelihood the landscape context may have really helped us out there," he says.

Prescribed fire reduced woody fuel loads by 22–33 percent. Although this reduction was substantial, Cook and his team had hoped for more. If they had been able

to wait for lower humidity and a steady, light wind before burning, Cook predicts that consumption of woody fuel and litter would have been greater. "We thought we would get more complete consumption of at least the finer fuels than we did," Cook continues. "We didn't even consume the entire littler layer, or even close to it which was a little surprising. But that's a good indication that the fire intensity wasn't anywhere near the level where unacceptable effects would start occurring. I think in the future we can ramp it up a little bit, still do it safely and not cause any harm to the system."

Where protection of the overstory was of paramount concern, removal of fresh litter around the trees proved to be highly effective, at least under the conditions of their burns. They determined that the pine mortality resulting from previous prescribed fire was caused by thicker than average litter due to a century of fire exclusion. Cook suggests that low- to moderate-intensity prescribed fire could safely be used to remedy the situation, as well as for a variety of other objectives.

Low-intensity fire awakens the understory

The unexpected extension of the pre-treatment period yielded new information about how low intensity fire affects diversity and abundance in the understory layer of these northern forests where resources needed for new plant growth are only available for a short period each year.

Cook was particularly interested in what's known as the 'spring ephemeral' component of the understory: plants that emerge in early spring then mature and decline by early summer when they're replaced by plants that emerge later in the growing season. Previous studies in the spring group were done in deciduous hardwood stands where there are no leaves or cover in early spring. Cook wanted to look into how this group responded in perpetually shaded evergreen forests like the old-growth white pine stands of the study area. He says, "We were curious—will the spring and summer groups in this forest system respond differently to our treatments? The answer is clearly *yes*."

Not surprisingly, the burns resulted in a fifty percent decrease in cover the first year for the spring ephemeral group, but by the following spring, cover had multiplied twelve-fold. The results for the herbicide + mechanical treatment lagged behind and weren't quite as dramatic, but the increase was still significant. Unlike the spring group, the summer group had its strongest response the first year, as the treatments took place long before their first stems breached the soil. By the second year both groups had responded very strongly, with increased richness as well as cover. There was a greater number of species in both early and late season groups relative to unburned areas. These effects have persisted for over five growing seasons, generating a significant increase in understory biomass and greater richness overall.

Adds Cook, "Fire stimulated the understory from a biodiversity standpoint which is probably positive for plant and animal interactions, providing more browse and more flowers for pollinators and insects. These are likely to be very positive outcomes for a variety of resource objectives."

(Left) Low-intensity prescribed fire burns through a treatment unit. (Right) Vigorous understory regrowth in burn unit five years after the study.

He further explains how low-intensity fires appear to drive the persistence of a diverse understory in these forests. "When these fires were occurring in different periods and different areas across the landscape they would have had a pronounced effect on the maintenance of diversity and at the local and landscape level," he says. "Historically, many of these understory plants that appeared after our burns probably migrated around the landscape with the help of fire as one way of maintaining their populations."

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Sleeper result—Delayed sapling mortality

A year after treatment, results were very different when it came to sapling mortality in the two treatment types. The mortality in the herbicide + mechanical treatment was 2 1/2 times greater than in the burns. In addition to the direct mortality, the mechanical treatment pushed the majority of stems at least 45º from vertical, and a year later they were still holding this angle. All units were surveyed again two years after treatment, which revealed significant levels of 'delayed' mortality in the burned units; many more saplings had died during the second year than the first.

"I thought that if they were going to be killed that the effect would be pretty immediate," Cook says. "They would either die that year or survive. We're talking about one half to one inch saplings. So to have a large percentage of the mortality not show up until the second growing season was certainly unexpected."

But the average cumulative mortality was still higher in the herbicide + mechanical units, where it was 80 percent—versus 63 percent in the burned units. The mechanical portion of the treatment also resulted in increased surface fuels. Cook emphasizes that anchor chain dragging is definitely not an effective fuel reduction

technique for forests with a moderate to high density of saplings. “The overall effect is to take a bunch of live fuel, kill it and lay it on the ground,” he says.

Mechanically treated units like the area shown above had over twice the cumulative mortality than burned areas.

Low-intensity fire may have more to offer

The information gleaned from this work has direct applications for landscape level bio-diversity and the role that natural disturbance plays in shaping it. Cook adds that although we need to study a much longer response period as well as varying intensities of fire, these results are a big first step.

He doesn’t see the use of high-intensity, stand-replacing prescribed fire as an option in the quest to stimulate natural white pine regeneration in the region. “In many areas that’s exactly what managers are deathly afraid of,” he says. “Realistically we aren’t going to be able to perpetuate white pine that way. It’s probably not feasible, so it’s important to continue examining whether we can do it with these low to moderate-intensity fires somehow. I think there is still quite a bit of potential in that regard.”

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Cook says it’s important to maintain what we’ve got and restore what we can in these northern Midwestern forests, although he doesn’t expect that white pine forests will ever be close to what they were. “But even with modern regulatory and societal constraints dictating where we can change things on a large scale,” he concludes “I like to think we can at least move it back in that direction.”

Management Implications

- Low-intensity prescribed fire stimulates a very strong understory response in terms of cover and richness, and can likely be used to support a wide variety of management objectives.
- It’s likely that moderate-intensity prescribed fire can be used safely in northern ecosystems of the Great Lakes region that have a white pine component.
- Where protection of the overstory is a paramount concern, removal of the fresh litter around trees is highly effective.
- Dragging of anchor chains is not a potential fuel reduction technique for forest systems that have a moderate to high density of saplings. In this study, the net effect of this treatment was to take a sizable live fuel component and transfer it to 10-hr and 100-hr dead fuel classes.
- Low-intensity fire is suitable for modest, incremental reduction of woody fuels.

Further Information: Publications and Web Resources

Link to final report: *Evaluation of Three Fuel Management Treatments for Eastern White Pine*: http://www.firescience.gov/projects/00-2-35/project/00-2-35_final_report.pdf

Galbraith, Betsy M. 2005. Understory Abundance, Richness and Diversity: An Assessment of Abiotic and Biotic Factors Influencing Understory Vegetation in Managed White Pine Forests of Northeastern Wisconsin. Master Thesis. University of Wisconsin at Stevens Point.

Scientist Profile

Dr. James E. Cook is a Professor of Forestry at the College of Natural Resources, University of Wisconsin-Stevens Point. In addition to advising Forest Management students for more than 15 years, Dr. Cook instructs courses in Ecology, Fire Management, and Silviculture. He also serves as the advisor to the UWSP Fire Crew. He has led tropical ecology workshops in Costa Rica and environmental studies programs in Germany and Poland. His research interests include disturbance, succession, regeneration ecology, and diversity.

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