Joint Fire Science Program

Fire Science Brief

RESEARCH SUPPORTING SOUND DECISIONS

Project in southeastern Missouri evaluated the results of both overstory thinning and prescribed burning, as well as a combined approach, as seen here. Photo by Jeremy Kolaks.

Testing the Conventional Wisdom: Fuel Management Approaches for the Central Hardwood Region

Summary

It's not for nothing that Missouri calls itself the "Show Me State." The name implies a common-sense insistence on seeing the evidence, an interest in seeing the proof. Thus, it is appropriate that an important long-term forestry research project is taking place in Southeastern Missouri. The goal is to test widely held opinions on the role and effectiveness of various forest fuel management strategies.

Research results continue to be collected on the effects of overstory thinning and prescribed burning on forest fuel-loads, and on using these tools to change the permanent character of the forest itself. The project began in 2001 and already is yielding important clues on forest change through prescribed burning and by manual thinning, as well as using a combined approach. Research is also developing information on the influence of aspect (slope and exposure) on forest modification by prescribed burning and by thinning. Investigators believe the results being uncovered here will have broader applicability within the Central Hardwoods Region of the U.S.

Key Findings

- The presumption of greater fuel accumulation on protected slopes was not found to be the case on these sites.
- Increased initial fuel loads resulting from thinning operations were confirmed.
- Thinning operations resulted in a reduction in litter levels.
- It was proven practical to perform specific species removal through overstory thinning.
- Overall reduction of fuel loads was achieved by burning, both in the thinned and non-thinned areas.
- Greater overall fuel consumption using prescribed burns on sloped areas was proven.
- Fuel consumption of the larger fuel sizes was found only on sloped areas.
- Flame length and rate of spread was greater on exposed slopes than protected slopes or ridge tops.
- Post treatment flora diversity in thinned-only areas was shown to be only slightly increased.
- Flora diversity was notably increased through burning.
- Fuel levels in burn areas returned to pretreatment levels within two years.
- The long-term effectiveness of both overstory thinning and prescribed burning for restoration of the original forest cover continues to be studied.

Project background

Description of study area

The research area is in the central Ozarks region in southeastern Missouri. Steeply rolling terrain has typical slopes of 10 to 35%. The region is about 85% wooded. Elevations range from 600 to 1,000 feet.

Project included extensive evaluation of the effects of slope and exposure on fuel levels and burn intensity. Photo by Jeremy Kolaks.

The initial principal investigator for the project was Edward Loewenstein, at the time with the North Central Research Station of the U.S. Forest Service. Keith Grabner from the U.S. Geological Survey and George Hartman (now retired) from the Missouri Department of Conversation helped design and execute the project. According to Loewenstein, a major distinguishing factor of the forest in this area is its xeric nature. He notes, "The shade-tolerant mesophytic tree species that are very common competitors to the east of the Mississippi are much less competitive here. Another notable feature is the lack of yellow poplar. This distinguishes the Ozarks from the interior highlands, the Cumberland Plateau in Tennessee, and northern Alabama."

Forest history

The forest type before settlement by European-Americans was open woodland, with dominant species being oaks, hickories and shortleaf pine. Removal of forest cover began with the ridge tops and valley bottoms, which were placed into cultivation in the 19th century. The steeper hillsides were logged to varying degrees during the period 1880–1920.

This region was selected for this project because of its topographic diversity, its typical forest and its herbaceous cover. The steeply rolling topography allowed evaluation of the influence of aspect in prescribed burning. Field work began in 2001. Loewenstein indicates that plot locations and the location of the study itself make the data collected especially applicable to the oak-dominated forests, woodlands and savannas on the western part of the Central Hardwood Region. He explains, "These systems evolved under the influence of fire, but have changed in character under fire exclusion and the exploitative timber harvests of the last 100 years."

Regional trend toward increased fuel loads

The subsequent principal investigator for this project was John Kabrick, a research forester with the U.S. Forest Service Northern Research Station in Columbia, Missouri. According to Kabrick, a broad trend in forests in the Ozarks is a long-term history of fire exclusion. In this study area, forests are typically still dominated by oak-hickory stands, but the high stand density and leaf litter accumulations have reduced the abundance and diversity of the ground flora. Experimental techniques studied were believed to have value for reducing stand density and leaf litter, an important fuel type in this region.

Project objectives

According to Kabrick, this was an exciting project because it provided the opportunity to test and quantify some of the practices becoming widely used in modern forest management. "Overall, it is fair to say that not a lot was known about fuel loads, fire behavior, and plant responses in the Ozarks. Managers have a sense of what should happen based on personal experience, but there has been very little quantification to date."

According to Kabrick, the project had three specific objectives:

Objective 1 was to measure the impact of both overstory thinning and prescribed burns on fuel loads, with specific attention to changes on protected versus exposed slopes. Kabrick says that the belief has been that greater moisture levels and lower temperatures of north-facing slopes may retard decomposition of litter fuels, allowing them to accumulate. Preliminary results indicate that both methods cause an immediate reduction in fuel loads, with most of the reductions being in the 1-hour and 10-hour classes.

Objective 2 was to evaluate the response of ground flora to burning and overstory thinning. Kabrick indicates that some managers have argued that increased light levels reaching the ground after thinning are as effective as burning for improving ground level flora diversity. Results to date indicate that diversity of ground flora is only slightly increased by overstory thinning, but burning does cause an important increase in flora diversity.

Objective 3 was to evaluate flame height and rate of spread in prescribed burns, comparing behavior on exposed slopes, ridge tops and protected slopes. This would provide better base information for fire management techniques. In the research, it was determined that flame height and rate of spread were significantly greater on both protected and exposed slopes, as compared to the more level ridge tops.

Project design

Project area description

The project was designed to include three separate experimental blocks, each approximately 135 acres (55 hectares) in size. Each block was divided into four treatment areas—control, prescribed fire only, overstory thinning only, and overstory thinning with prescribed fire. The goal was to gather data on the relative long term effectiveness of prescribed burning and thinning as techniques to modify the characteristics of the forest.

Pre-treatment data collection

An important element of the project was to collect detailed information on the characteristics of the plots before any modification or treatment. Permanent vegetation subplots were installed in the summer of 2001. Three overstory subplots were established within each treatment/aspect class. These were each 0.25 acre (0.1 hectare) in size. For woody regeneration study, fifteen circular 0.025 acre (0.01 hectare) plots were established within each treatment/aspect class. For evaluation of ground flora, one 11 sq. ft. (1 m^2) quadrat was used.

Fuel data were collected at 15 randomly located points within each treatment/aspect area by Jeremy Kolaks, then a graduate student working under Dr. Bruce Cutter of the University of Missouri's Department of Forestry. Woody fuels were sampled by fuel timelag class.

Within each of the study blocks, three aspect categories were studied. These were protected slopes, exposed slopes, and ridge tops. According to Kabrick, the initial supposition of higher fuel loading on protected slopes because of greater litter accumulation and lower decomposition was not proven.

Fuel reduction treatments

Fuel reduction treatments by thinning were conducted in the summer and early fall of 2002. Stocking of thinned stands was reduced to 40 ft^2/acre (3.7 m^2/ha). After the initial removal of commercial timber, non-commercial trees were felled by hand crews. Fire-tolerant species were the preferred leave-trees. These included white oak, post oak, and shortleaf pine. Logging slash and the felled non-commercial trees were left in place.

Commercial logs were removed from the overstory thinning sites. Photo by Jeremy Kolaks.

Initial prescribed fire treatments were conducted before leaf-out in the spring of 2003 by Missouri Department of Conservation employees. Prescribed fire weather was measured and recorded every fifteen minutes, using an automated weather station. Prescribed burn weather and fuel condition parameters were as follows:

Attribute	Prescription
Temperature (°F)	45–65 (7–18°C)
Mid-Flame Wind (mph)	0–7 (0–11 km/h)
Relative Humidity (%)	25–45
Fuel Moisture (%)	
1-hr.	5–10
10-hr.	8–15
100-hr.	12–18
1000-hr.	>20

Prescribed fire data collection

Flame data was collected by Jeremy Kolaks of the University of Missouri. Flame height is an important aspect of prescribed fire data because it is a good indication of the

intensity of the burn and its effect on overstory vegetation. In this project, flame height was measured at three randomly chosen fire behavior plots out of the 15 fuel sampling stations within each stand.

A second prescribed fire characteristic, rate of spread, was measured using rate of spread clocks. These were constructed from digital sport watches and were modified with a solder trigger. The watch assembly was buried with the trigger above the soil surface. The trigger was activated when the flame front melted the solder. Five of these were installed in each fire behavior plot. Unfortunately, only a fraction of the rate of spread clocks worked properly. Data on rate of spread was instead calculated using estimates of fire intensity and the amount of energy released by 1-hr fuels.

Project results

Vegetation data

Overstory Thinning Results—All study plots were fully stocked stands dominated by oak and hickory species. Pretreatment tree density ranged from 241.6 to 485.5 trees/acre, with a mean of 357.4 trees/acre. Pretreatment basal area ranged from 79.5 to 146.2 ft^2/acre (7.4 to 13.7m^2/ha). The thinning operation removed on average 101.8 trees/acre and 57.7 ft^2/acre. Thinning treatments reduced stand stocking by an average of 59.1 percent.

Thinning operations reduced site stocking by an average of 59.1 percent. Photo by Jeremy Kolaks.

Kabrick points out, "As expected, the thinning operation increased the fuel loads, but until now, no study had quantified the magnitude of the increase. The study showed that fuel loading increased by 300 percent." He notes that the study also showed that the litter component was actually reduced by equipment used in thinning operations. All plots initially contained the same dominant species: hickory, flowering dogwood, white oak, black oak , and black gum. The thinning process increased the total relative basal areas of shortleaf pine scarlet oak, and post oak, and these species had a greater proportional abundance following the thinning.

Post oak and shortleaf pine were retained during thinning operations on ridge and exposed slopes because they are fire tolerant and tend to occur in these exposures. On protected slopes hickories, flowering dogwood and black gum were favored for removal because of their fire intolerance and high abundance in these exposures.

Prescribed burn results

For the most part, prescribed burns were conducted within the prescribed conditions, although in some cases humidity dropped below prescription levels after ignition operations were completed. Weather and 10-hr fuel moisture levels were recorded by an on-site automated weather station. One, 100, and 1000-hr fuel moistures were calculated using data from two nearby automated weather stations.

Fuel consumption patterns

Prescribed burning reduced fuel loading and vertical structure in all aspect categories, in both thinned and unthinned treatments. Fuel consumption decreased as timelag size class increased. Consumption levels did not significantly vary among the three aspects for either treatment. However after the initial prescribed burn, the data suggested that a greater proportion of consumption occurred on exposed slopes in the 1, 10, and 100-hr timelag classes than on ridges or protected slopes.

In all cases, nearly 100% of litter was consumed. Litter was responsible for consumption of about 90% of all fuel <¼ in., and about 75% of all fuel <3 in. for unthinned sites, as well as 75 and 50% respectively, for thinned sites. Fuel consumption in the 100-hr, 1000-hr solid, 1000-hr rotten, and duff depth consumption categories was not significant for both treatments on most aspect groups. Higher intensity fires on the slopes on the burn-only areas caused some consumption of 1000-hr fuels.

Burn-only vs. burn-thin comparisons

According to Kabrick, there was little significant difference in average fuel consumption between thin-and-burn and burn-only areas in the three aspect categories, with the exception of greater solid 1000-hr fuel consumption in the thin-and-burn category in all three aspect classes. Because of overstory clearing, there was much more 1000-hr fuel at and near ground level in the thin-and-burn category.

Because of overstory clearing, there was more 1000 hour fuel at ground level in the thin-and-burn cateqory sites. Photo by Jason Jenkins.

Fire behavior results

Data gathered in the prescribed burn stage indicates that fire behavior including flame length and rate of spread appears to be related to aspect. Both the flame length and rate of spread were greater on south-facing (exposed) aspects than on ridges or north-facing (protected) sloped. According to Kabrick, this result was not unexpected, but this study allowed confirmation and documentation of this behavior often observed by managers.

Effects on ground flora vegetation

One area of controversy into which the results are providing new insight is the relative effect of overstory clearing versus burning on increasing the diversity of ground flora. Kabrick notes that in the past, some have argued that higher light levels from thinning would be as effective as burning for increasing the diversity of ground flora. Following the initial burn and thinning treatments, data was collected on the response of ground flora by Erin McMurry, another graduate student advised by Dr. Rose-Marie Muzika of the University of Missouri Department of Forestry. Data evaluated by McMurry show that the thin-only treatment has had consistently less impact on increasing the relative richness of ground flora than burn-only and thin-and-burn treatments.

Continuing site studies

Kabrick indicates that most managers believe it will require several burns over a period of years to bring plant and tree communities into a kind of successional equilibrium that will have many of the characteristics the area had before settlement by European-Americans.

He notes that fuel loads, particularly the litter and 1-hour fuels, return to pre-burn levels quite quickly. This is why the study was designed to have multiple burns over a ten-year period. Kabrick notes, “We will have a better sense of how long it takes to reach equilibrium by the tenth year of the study.” He explains that most Ozark woodlands had a history of being burned by Native Americans for thousands of years, and then also by settlers until fire suppression efforts were initiated in the 1930s.

Second burn completed

Second burns were performed on the same plots in 2005, two years after the initial burns. There was no additional or supplementary hand or mechanical clearing done on the sites. In the burn areas which also had received overstory clearing, the stumps of some of the thinned trees have sent up sprouts, some of which were killed by the second fire.

It is hoped that this project will help develop long-term information such as the number of burns needed to restore the initial character of the forest. Also researchers are hoping to find out what damage is caused to the residual timber stand during fire treatments, and what impact this will have on timber value. Researchers also hope to determine whether this impact varies by aspect and thinning treatment. They also hope to find out more precisely how quickly forest fuel loads return to pre-burn levels.

Management Implications

- Forest managers in the Central Hardwood Forest region can expect fuel levels to return to pre-burn levels within two years of an initial prescribed burn.
- In working to increase flora diversity, prescribed burning will be noticeably more effective than overstory thinning only.
- Total fuel consumption levels will be higher on sloped areas rather than flat areas.
- Expect that it will take multiple burns to bring forest successions back to a mix similar to that which existed before settlement by European-Americans.
- Thinning operations will result in changes in the litter component of fuel on the forest floor. This is a result of vehicle traffic and timber being dragged, thus crushing and redistributing the litter. This creates more irregular burning patterns than in un-thinned areas.

Relation to other research

Kabrick indicates that work done here complements other research done in the state of Missouri and elsewhere. He cites work being done in Minnesota on the effectiveness of fire for restoring and managing mixed pine woodlands, and other work in Ohio and Pennsylvania on the use of prescribed fire for regenerating oak woodlands. Loewenstern adds that at the time this study was initiated, very little information was available concerning fuel loads, fire behavior or ecosystem responses to fuels treatment. He notes, “This study provides baseline data on all of these issues and examines quantitatively the efficacy of some of the approaches that were already being discussed and in some cases applied in the region.” He is hopeful that the longer-term research will give natural resource managers the information needed to determine whether thinning, fire or a combination of the two will give the results they seek in the way of fuel reduction, forest structure, and herbaceous vegetation diversity.

Further Information: Publications and Web Resources

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Scientist Profiles

John Kabrick is a Research Forester at the USDA Forest Service, Northern Research Station in Columbia, Missouri. His research interests include the ecology and silviculture of forests and woodlands of the Central Hardwood Region.

John Kabrick can be reached at:
Northern Research Station
202 ABNR Bldg., University of Missouri-Columbia
Columbia, MO 65211-7260
Phone: 573-875-5341 x.229
Email: jkabrick@fs.fed.us

Edward Loewenstein is an Associate Professor of Silviculture at Auburn University. His research interests include all aspects of uneven-aged silviculture.

Edward Loewenstein can be reached at:
School of Forestry and Wildlife Sciences
Rm 4431 SFWS Building
Auburn University, AL 36849-5418
Phone: 334-844-1069
Fax: 334-844-1084
Email: loewenstein@auburn.edu

Collaborators

Keith Grabner, Ecologist, U.S. Geological Survey
George Hartman, Fire Ecologist, Missouri Department of Conservation (retired)
Jeremy Kolaks, Graduate Student, University of Missouri
Erin McMurry, Graduate Student, University of Missouri

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John Cissel
Program Manager
208-387-5349
National Interagency Fire Center
3833 S. Development Ave.
Boise, ID 83705-5354

Tim Swedberg
Communication Director
Timothy_Swedberg@nifc.blm.gov
208-387-5865

Writer
Jake Delwiche
jakedelwiche@earthlink.net

Design and Layout
RED, Inc. Communications
red@redinc.com
208-528-0051