Joint Fire Science Program
Fire Science Brief
RESEARCH SUPPORTING SOUND DECISIONS

A black spruce fire heads for the highway in interior Alaska. Credit: D. Sandberg.

Fuels Treatment Demonstration Sites in the Boreal Forests of Interior Alaska

Summary

Wildland fire is the dominant disturbance force in the boreal forests of Alaska which cover about 114 million acres of the south-central and interior regions of the state. Fire in the wildland-urban interface (WUI) is an exceptionally daunting concern as a high percentage of Alaskans live in outlying rural areas and settlements. Fire hazard is growing as communities continue to expand into isolated locations surrounded by highly flammable black spruce. To address this concern, researchers developed the first shaded fuel break demonstration sites specifically designed for use in the WUI. They compared the effectiveness, environmental impacts and costs of four fuel thinning treatments, and found that widely spaced thinning carried some significant trade-offs, including increased fire spread rates and permafrost deterioration.

Key Findings

- Fire behavior trade-offs are significant when thinning Alaskan black spruce.
- When fire was modeled in shaded fuel breaks with conditions representing a hot summer day, the potential for crown fire was reduced by 80 percent—but the rate of fire spread doubled.
- Increased sunlight in treated sites killed feather mosses that insulate permafrost.
- Permafrost in treatment sites melted more deeply than in the control site, bringing potential for destabilization of structures and roads.
- Shaded fuel breaks in black spruce must be actively defended if threatened by fire.

Accommodating a hot-headed neighbor

All over America, people are literally heading for the hills when it comes to finding home. Drawn by the possibility of privacy, a little breathing room between neighbors and the presence of the natural landscape, America's wide open spaces are being encroached upon and settled into at a record pace. Increasingly, these new residents of forest and field are being introduced to yet another, not so peaceful neighbor—wildfire.

Areas where human habitation and activity intersect with the potential for wildfire are known as the wildland-urban interface (WUI). During fire season, the evening news is often peppered with video of families hastily packing their lives into their cars, evacuating neighborhoods shrouded in smoke. Eighty percent of Alaskans live in the WUI and are potentially at risk for this same scenario. As it is with their fire-threatened neighbors in the lower 48 states, this is a relatively recent phenomenon, but the causes behind it have some differences.

Fire was and remains as much a part of America's last frontier as the midnight sun and the Northern Lights. Historically, wildfires and Alaska's rural residents had a better chance of missing each other. The state's remote wildlands were dotted with native villages and the camps and cabins of trappers and miners. Although wildfire certainly impacted these enclaves on occasion, there was less infrastructure for fire to consume. In 1959, the Alaska Statehood Act brought some changes to human settlement patterns. This legislation transferred hundreds of thousands of acres of federal land to state and local ownership. New roads were constructed allowing development in areas that were previously only reachable by air. Some seasonal camps and villages were abandoned while others grew into permanent towns—which brought along modern amenities like schools, power and water facilities, airports, fuel storage, transportation infrastructure and other commercial properties. Although Alaska still has a lot less WUI than the lower 48, communities are expanding further into fire's domain—the flammable black spruce forests that dominate Alaska's interior.

Thinning thickets of black spruce.

Thinking thin

"This settlement pattern will likely result in increased damage from typical fires," says Fire Ecologist and Principle Investigator Randi Jandt of the Alaska Fire Service, based in Ft. Wainwright, AK. "We expect continued dispersed settlement into at-risk forested areas as more state and federal public lands are conveyed into public hands. A trend toward shorter fire return intervals and larger fires all across the North American boreal forest will increase the fire-WUI problem in Alaska."

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Proactive creation of defensible space has become a priority. Although fire protection agencies have created fire breaks and shaded fuel breaks around some vulnerable areas, their effectiveness hasn't been formally monitored or compared. One fire break is credited with keeping the residential area of Ft. Greely safe during the destructive Donnelly Flats Fire in 1999, but little is known about how various treatments compare with regard to effective community protection or ecosystem effects.

Jandt teamed up with Dr. Robert Ott, formerly of the Alaska Department of Natural Resources Forestry Division and the Tanana Chiefs Conference Forestry Program. The Tanana Chiefs Conference is a non-profit tribal consortium of 42 native villages in interior Alaska. Many of theses communities and allotments are the type of settlements the team hopes to protect through the results of their studies.

With this project Jandt and Ott jumpstarted the process of determining which treatment methods work and which ones don't—and identifying the associated impacts across affected environments and communities. Their goal was to create the first fuels treatment demonstration sites in interior Alaska's boreal forests—specifically in stands of black spruce in floodplains. Thinning was their treatment of choice.

"Thinning was the most viable, so it was the first thing we tried when we started getting into this work," says Jandt. It was also more acceptable to the communities than other, more drastic treatment options. "Thinning around these settlements was much more preferable than just going in there with a bulldozer and clearing everything out, which isn't very aesthetic," she adds.

Thinning also made sense because the researchers wanted to protect the sensitive permafrost—an unseen, frigid layer that forms the foundation for forest and human communities alike across much of the state. Permafrost is defined as solid ground that remains below 32°F for longer than two consecutive years. This frozen soil acts as a barrier to the movement of water and occurs in flat, lowland areas or on north or east facing slopes where direct sunlight is scarce. The deepest portion of permafrost can remain frozen solid for thousands to tens of thousands of years. Its upper reaches—known as the *active layer*—thaw and re-freeze to varying degrees with the passing seasons. This layer binds up water when it's frozen and releases it back in to the system when it thaws. Permafrost is insulated by layers of organic soil and moss that act much like the top on a picnic cooler. Remove the top and your ice melts—and the consequences for Alaskan communities of humans, plants and animals are significantly more serious than warm beer.

"If a house or village has a lot of permafrost underneath it and you scrape off that organic layer you've removed the insulator that keeps that frozen. It starts to melt, which can make everything from building foundations to roads rather unstable," Jandt explains. Thinning is much less drastic and leaves the organic layer alone, which made it a sensible treatment to test.

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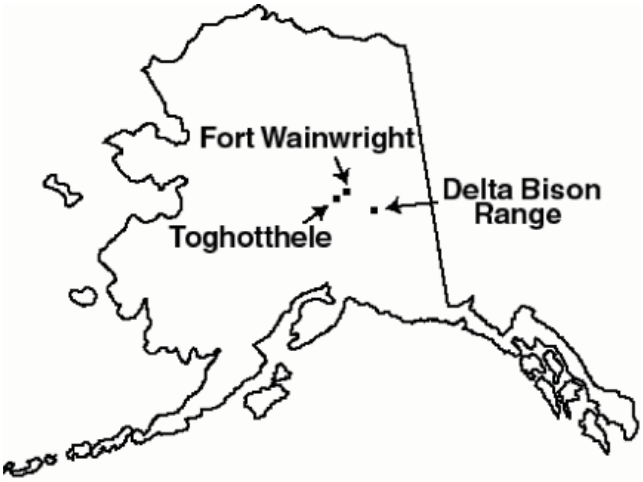
Thin, watch and learn

The researchers thinned trees in a range of densities to create shaded fuel breaks and modeled the effectiveness for reducing fire behavior. They evaluated different density and pruning variations to see not only how fire might behave in each, but what was likely to happen in the natural environment over time with fewer trees and more sunlight.

Three duplicate demonstration sites were created in the Tanana River Watershed. Treatments were applied in 2001 by the Alaska Fire Service at the Ft. Wainwright site, and by foresters from the Tanana Chief's Conference at the Toghotthele site near the native village of Nenana. The Alaska Division of Forestry created the treatments at the Delta Bison Range in 2002.

Each demonstration site was created in a black spruce stand and consisted of five, one-acre treatment blocks. Each block was randomly assigned to receive one of the following five fuels treatments:

- **Treatment 1**: Trees thinned to 8 feet by 8 feet spacing (680 trees per acre).
- **Treatment 2**: Trees thinned to 10 feet by 10 feet spacing (435 trees per acre)
- **Treatment 3**: Same as Treatment 1 with residual standing trees pruned to 4 feet to increase the base height of ladder fuel.
- **Treatment 4**: Same as Treatment 2 with residual standing trees pruned to 4 feet to increase the base height of ladder fuel.
- **Treatment 5 (Control)**: No trees were cut or pruned.



Locations of black spruce fuels treatment demonstration sites in interior Alaska.

Slash was piled and burned during the winter or removed from the sites.

Pretreatment surveys and photographs were taken in each block, including the control. The permafrost active layer was measured in September of the first year, which is the time of year when it has thawed as deep as it's going to go. Two years later everything was measured and photographed again. Data included tree information, seedlings, understory vegetation, ground cover, duff and active layer depths, down woody fuels and microclimates. Fire behavior was modeled for treatment and control using

the crown fire hazard analysis software, NEXUS. NEXUS was designed to compare crown fire potential for different stands, and to compare the effects of alternative fuel treatments on crown fire potential.

A researcher pulls a duff core sample for analysis.

Thinning brings positives and negatives

The researchers discovered that there are significant trade-offs to thinning black spruce stands in an ecosystem that is so dependent on the delicate balance of heat, light, cold and shade. Fewer trees meant more sunlight which triggered a cascade of effects in treatment sites.

When fire was modeled on a hot day, the potential for crown fire was reduced by 80 percent—but the rate of fire spread doubled. Thinning restricted modeled fire behavior in tree crowns to occasional torching in most cases, with reduced fireline intensity compared to active crown fire in surrounding untreated stands. However, all stands remained well above thresholds for torching even on average fire weather days. In treatments where spacing was widest, the depth of the active layer increased somewhat but not nearly as much as it would following bulldozer treatments that scrape off the protective organic layer.

Surface fuel changes were another notable outcome. The most important surface fuel component in the region is feather moss which insulates the boreal forest floor. The moss layer, which may be up to a foot thick, keeps the warm air off the permafrost and is very sensitive to sun. “After you thin you get a significant die-off of these mosses,” explains Jandt. “Initially it gets all crunchy and crispy, so you can imagine what that does for fire behavior in the first couple of years. They are already highly flammable in their green state, and dry rapidly when relative humidity is low. So there are still some big trade-offs to doing this kind of thinning in Alaska. We’re seeing that the treatments can create totally new and different fuelbeds.”

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Loss of the surface mosses allows the ground to heat up and the active layer to deepen somewhat in summer. “This is evident in the treatments right out the door behind me,” says Eric Miller, another Forest Ecologist based in Ft. Wainwright. “In most areas the active layer is increasing and there’s more standing water from melting permafrost. There appears to be a gradient from the control on up. In the control the active layer is pretty shallow—but in the 10 by10 pruned treatments things are pretty mushy. It’s hard to walk through.”

Thinning allows more direct sunlight to reach the ground, often killing feather mosses that insulate permafrost.

Eventually that extra moisture dries out. Any remaining mosses vanish and the grasses arrive. Wind speed increases too because there are fewer trees to intercept its flow. This dries out the vegetation even further and has led to wind-throw on some sites. A few more years of observation is needed to see if all this warming, wind, sogginess and eventual dryness will affect the trees that remain. According to the model, each of these changes will contribute to faster moving flames if fire were to pay a visit.

There are some potential benefits to these treatments however. Treated areas are more open and accessible for aerial suppresion efforts should a fire occur. There is potential for the black spruce to convert to more fireproof hardwoods over time in areas where that is an objective. Jandt adds that they did see some relief with lower potential for crown fire initiation when they modeled these treatments. She notes however, that the bottom line is there will always be some torching and passive crown fire behavior in black spruce because of their structure and the surface fuel types. Low-intensity surface fire easily ignites low growing branches, giving flames a straight shot through continuous fuel to the tree crown.

Jandt still questions whether the models are right: "Do we really believe the fire behavior models? We modeled these on lower 48 thinning treatments. Most of the fuels prescriptions come from the lower 48, and we've never had the opportunity to burn one of these things," she notes. "We've put them in operationally in neighborhoods and communities where a prescribed burn isn't really an option."

Thinning must include defense

Jandt points out that thinning and pruning still leave more shade than bulldozing or shear-blading, but conceded that some managers have decided that thinning just doesn't provide enough of a benefit because of the modeled rates of fire spread.

For those that choose to thin, she recommends that spacing be kept to eight feet where black spruce are less than six inches in diameter to reduce impacts on permafrost and risk of destabilizing structures or roads. Additional pruning of lower dead branches reduces ladder fuels while retaining shade and surface fuel moisture. Jandt emphasizes that managers and landowners should be prepared to actively defend treated areas either by pre-wetting the ground or burning them out if fire threatens. Given the trade-offs observed in this project, managers are experimenting with alternate versions of fuel breaks that they hope will be more effective in situations where actively defending treated sites is less feasible.

"We don't know yet where all this will end up," Jandt says. "It's important that we keep looking at the changes that are happening in these open stands. Thinning treatments in boreal forests are bringing a lot of interesting vegetation dynamics that illustrate how critical these studies are. We need to keep following it all to see what it does."

The demonstration sites allow people to visually compare the differences of various fuels treatments, and are available for anyone to visit.

The demonstration sites allow people to visually compare the differences of various fuels treatments, and are available for anyone to visit. State officials, resource management professionals, interested public and all of the interagency partners have readily taken advantage of the lessons they have to offer. There is no intention to burn the sites as they are intended to serve as long-term indicators of what will happen ecologically over the next couple of decades. But the record fire seasons of 2004 and 2005 emphasized the need to test model predictions experimentally by recreating the treatments and actually burning them. A prescribed burn planned for 2009 will do just that. Research and implementation partners from seven agencies are waiting for the right conditions to conduct the Nenana Ridge Experimental Fuel Break Burn—which features both thinning and shear-blading treatments.

Jandt jokes that the perfect black spruce fuel treatment would be to "just send a bunch of two-foot tall robots in there to trim off the lower branches of all these spruce trees and remove all the surface fuel. That would be ideal." But pending the invention of and budget for these high-tech treatment confederates, Jandt and her colleagues continue to refine their knowledge for the benefit of Alaska's expanding human communities and natural communities alike—in the ongoing quest to balance natural processes and the protection of life and property in this landscape of fire and ice.

Management Implications

- Recommended spacing for thinning treatments is 8 feet by 8 feet in black spruce, with additional pruning to reduce ladder fuels.
- Because of the potential for increased rates of spread, active defense of treated areas is recommended if they are threatened by fire.

Further Information: Publications and Web Resources

Fuels Treatment Demonstration Sites in the Boreal Forests of Alaska Final Report—Joint Fire Science Program No. 00-2-34: http://www.firescience.gov/projects/00-2-34/00-2-34_final_report.pdf

An Analysis of Shaded Fuel Breaks on Fire Behavior: http://fire.ak.blm.gov/content/effects/tfmproject.pdf

Using NEXUS to Assess the Effectiveness of Experimental Black Spruce Forest Fuel Breaks to Reduce Crown Fire Potential in Alaska: http://fire.ak.blm.gov/content/effects/NEXUS 2007 AKFuelRX_EAH.pdf

Alaska Department of Natural Resources, Forestry Division: http://forestry.alaska.gov

Alaska Fire Service: http://fire.ak.blm.gov/afs

Scott, J.H. 1999. NEXUS: A system for assessing crown fire hazard. *Fire Management Notes* 59(2):20-24: http://www.fire.org

Tanana Chiefs Conference: http://tananachiefs.org

Scientist Profile

Randi Jandt is a Fire Ecologist with the Bureau of Land Management, Alaska Fire Service based in Ft. Wainwright. She has over 20 years of field experience in Alaska as a firefighter, wildlife biologist and ecologist and is currently working on documenting fire effects in tundra and boreal forest fires and long-term effects of fuel treatments and prescribed fires.

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