Alaska Fire Science Consortium

Webinar Summary

This study addressed the response of northern black spruce boreal forest ecosystems to fire disturbances and how changes in fire return intervals can alter successional trajectory.

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Presenter:

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Paper from Ecology and Management:

Brown, C.D., and Johnstone, J.F. 2012. "Once burned twice shy: Repeat fires reduce seed availability and alter substrate constraints on Picea mariana regeneration". 266: 34-41.

Once Burned Twice Shy: Repeat Fires Result in Black Spruce Regeneration Failure

Species like black spruce have adapted a regeneration strategy as a way of enduring after natural disturbances like fire. Black spruce trees rely on a semi-serotinous regeneration strategy, where a fire can trigger a large seed release. Black spruce seeds are contained in an aerial seed bank at the top of the tree, which opens in response to heat from a fire. Northern boreal forests act on a natural disturbance cycle of around 80-150 years. The purpose of this project was to better understand the impacts of changes to that cycle. An increase in frequency and intensity of wildfires are expected due to climate change.

Location: The ecosystem studied was a black spruce forest in the northern Yukon along the Dempster Highway. Black spruce trees are very slow growing—it takes 20-30 years to reach reproductive maturity—making them particularly vulnerable to repeat burns.

What happens when black spruce forests burn before they reach reproductive maturity?

This study looked at patches of forest with three fire history variants: 1) patches that burned in either 1990 or 1991 and had a typical long fire return interval (FRI); 2) patches that burned in '90 or '91 and again in 2005, with a short FRI of about 15 years; and 3) patches with no recent burn history that were established mature forests. Experimental sites were set up in each fire history area:

- Short Interval (15 year FRI)
- Long Interval (100 year FRI)
- Mature Forest (no recent fire history)

Another important characteristic of the entire study area is that it is underlain by continuous permafrost, which creates a stratified hummock-hollow micro-topography. Hummocks have lower soil moisture and thinner soil organic horizons (forest floor layers above mineral soil) than the hollows that intersperse them. Water drains down into hollows, creating a thick

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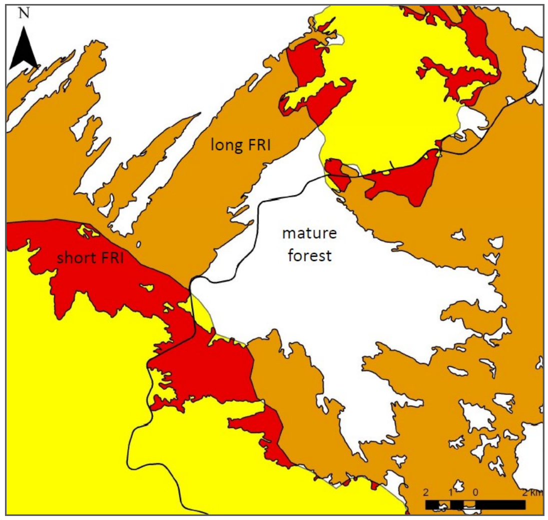
Fire History Study Areas:

Mature Forest: Trees averaged 77 years old and had reached reproductive maturity; most maintained aerial seed banks; forest floor consisted of thick sphagnum moss or a mix of feathermoss and lichens.

Long Interval Burn: Burned in either 1990 or 1991 after about 100 years without fire; standing dead maintained aerial seed banks; some seeds established on the forest floor.

Short Interval Burn: Burned in either 1990 or 1991 **AND** again in 2005; all standing dead trees from 1990/91 fires were consumed in 2005 along with 10-15 year old seedlings; open grass/herbaceous landscape; no tree establishment.



Mature forest and long interval burn areas had similar seed availability; short interval burn areas had little seed availability.

matt of sphagnum moss.

To understand the full scope of the regeneration cycle in regard to fire return intervals (FRI), researchers focused on *seed availability* and *seed germination.*

Seed Availability

Over the course of three years this study used seed traps to measure how many seeds were dispersed onto the forest floor (number of viable seeds/ meter squared/year). Results showed mature and long interval burn areas had about the same amount of seed rain, while short interval areas had very little. Mature forest and long interval areas experienced similar distances to seed sources while short interval areas were approximately 50 meters from the nearest patch of at least 20 black spruce trees.

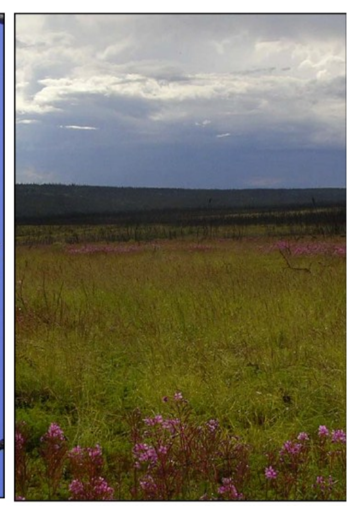
Seed Germination

The next step was to determine whether the seeds could germinate and survive. Researchers set up control plots to look at natural recruitment and test plots that were seeded. Seed emergence and survival were measured.

The control plots in long interval burn areas had some black spruce recruitment, more in hollows than hummocks. As

mature forest

long-interval burn



short-interval burn

expected, short interval burn areas had little to no recruitment due to lack of seed availability.

In the <u>seeded plots</u>, long interval burn areas had a substantial increase in seed recruitment in both hollows and hummocks. The short interval burned plots did just as well, suggesting **seed availability is the biggest constraint on black spruce stand self replacement.**

The mature forests, on the other hand, which had the same natural seed availability as the long interval sites, had very little seed recruitment in either controlled or seeded plots. Researchers found **the makeup of substrate was the key factor.** The mature sites had very thick moss and lichen layers, up to 30 cm deep, which are unsuitable substrates for black spruce seed establishment.

Substrate constraints were also found in short interval burn areas but in a slightly different way. Grasses and other herbaceous vegetation accumulated a build up of leafy litter. This build up creates the same substrate structure as lichens: very porous and dry, not suitable for seed germination.

Implications

<u>Wildlife</u>: Areas like this northern black spruce stand serve as caribou habitat. A shift from black spruce-moss to open grassy tundra has serious implications for mammals like caribou that rely on these grounds for subsistence.

<u>Carbon</u>: Trees and soil organic horizons are forms of biomass, which offer carbon storage. Boreal

Key Discoveries:

1. Constraints on seed germination are a key factor for seed recruitment. Mature forests struggle with germination due to buildup of lichens and moss (unsuitable substrate) over time. Short interval burn sites also struggle due to lack of seed availability and unsuitable substrate for germination (buildup of grass litter following repeat burn).

2. Repeat burns are particularly detrimental to self replacement when the second fire happens before black spruce seedlings can reach reproductive maturity: This eliminates seed stores.

These two factors together will likely cause long term disruption in these stands.

"Seed availability is the biggest constraint on black spruce stand self replacement."

A disruption of the historic fire regime (fire return intervals of 80-150 years) in northern boreal forests may reduce the advantage of a serotinous regeneration strategy.

Photo courtesy Yukon News.

Fire Effects on Carbon Cycling Following Two Closely Timed Fires:

- Decreased carbon storage
- Increased net carbon loss over a fixed period of time
- Increased risk of losing deep carbon stores

forests store huge amounts of terrestrial carbon, and a change in those storages (carbon released by frequent fires and loss of the biomass) could have serious global implications.

Fires in mature forests and long interval sites result in loss of carbon storage from wood biomass (Brown et al. Int. Journal of Wildland Fire, 2011). Short interval burn sites have no wood biomass but experience carbon loss from soil organic horizons. This results in both surface carbon loss from the surface layers and deep carbon loss. The soil organic horizons insulate the underlying permafrost and mineral soils. Repeat burns result in thinned soil organic horizons, which warms the mineral soils underneath. That heat in turn can melt the permafrost, thawing deep carbon stores. This is vital due to the amount of carbon in the permafrost zone. (Brown et al. Int. Journal of Wildland Fire, 2011).

Climate Change and Treeline Dynamics:

Increases in fire activity may lead to a degradation of treeline forests in some areas, rather than the increased tree density and forest extent predicted with climate warming.

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Questions

Q: Regarding your hypothesis about the state of these short interval stands, what are your thoughts about long-term regeneration?

A: We did see some stands that had been short interval burn sites from the 80s from a distance, and they hadn't come back as a forest stand. Something that I'd like to do in the future is to look at other marginal northern forest stands to see what is happening in such areas. I would expect the short interval stands in this study are not going to come back to forest stands.

Q: Did you detect deciduous tree establishment in these short interval burn sites? Do you have any idea of the potential role of broad leaf trees in short interval stands?

A: Currently there is not a seed source for deciduous trees that far north, but there is potential for seed travel in the region, especially along the highway; it is not likely in the short term though. An additional element of this field experiment involved the planting of other species seeds, such as white spruce, trembling aspen, Alaska birch, etc. in addition to the black spruce. We wanted to see what the potential was for shifts in successional trajectory if these burns weren't seed limited. In other words, if all seed was available what species would be best? These short interval burn areas are

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