AFSC Technology Transfer
SERDP Research Brief 2013-2

Threshold Dynamics in Alaska Boreal Ecosystems

R. Jandt, A. York and K. Timm

Department of Defense Funds Ecological Research on Interior Alaska Training Ranges

In late April 2013, scientists from universities in Alaska, Florida, and Saskatchewan met with fire managers and resource specialists to share early results from a study called **Identifying Indicators of State Change and Forecasting Future Vulnerability in Alaskan Boreal Ecosystems**. This project, funded by the Department of Defense Strategic Environmental Research and Development Program (SERDP), looks at military training lands in interior boreal forest ecosystems and surroundings. The objectives are to

- determine linkages among climate, fire, soils, permafrost, and vegetation succession,
- test field-based measurements indicating boreal ecosystem vulnerability to state change, and
- forecast landscape change in response to projected changes in climate, fire regime, and fire management.

Dr. Dave McGuire of UAF Institute of Arctic Biology, one of the project's principal investigators, explained that main thrust of the 5-year project is to find out more about major drivers of change, especially fire and its effect on organic soil depth, decomposition rates, and permafrost states. They are also interested in the impacts of management practices such as fire suppression, military training, and fuel treatments (shearblading and thinning) on boreal forest fire regimes. In 2012 the project sampled forest characterics, including stand age, on 16 managed sites on Ft. Greely and Eielson AFB. Mc Guire and colleagues are working to understand how management practices affect:

- moss-soil-litter feedbacks, especially on mid-successional sites,
- identifying possible "tipping points" for changes in forest type—like coniferous/deciduous switches,
- the possibility of "alternate" states, i.e. changes to non-forested vegetation, and the formation/loss of wetlands.

PhD student Xanthe Walker, University of Saskatchewan, summarized findings from studies on the recovery of 2004 fires. Briefly, higher fire severity (more organic layer consumption) led to more deciduous seedling (especially aspen) establishment. They are now working on quantifying the effect so it can be used in modeling efforts.

University of Florida scientist Dr. Michelle Mack migrates to Fairbanks every summer. She explained how to measure the organic depth removed by a fire after the fact--using adventitious roots on black spruce and tussock cores in tundra with allometric equations that have now been published (Boby, et al. 2010, Mack, et al. 2011). In very severe fires, it was expected that the deep layers of consumed duff would be very old--maybe having been locked in permafrost for centuries! Her radiocarbon dating studies proved otherwise, however: generally the bottom of organic layer in boreal forest was about the same age as the stand. In tundra the deepest consumed layers averaged about 50 years, displaying the "bomb signature" of radioactive C from the 1940's.

Prescribed burn, Ft.Richardson, Alaska, 2006. Photo by R.Jandt.

University of Saskatchewan M.S. Student Matthew Frey reported findings on weeds in burned areas. Surveys for invasive species along the Dalton Highway yielded nothing in mature stands, but 33% of burned stands sampled had dandelion (*Taraxacum*), hawkweed (*Crepis*), or white sweet clover (*Meliotus*). Remaining organic layer depth seems to be the largest factor in predicting post-fire susceptibility to invasive species. Weeds establish better on thin organic layers or mineral soil, similar to birch seedlings, and birch seedling count may be a good surrogate for invasive plant establishment potential. While most weeds are tied to disturbed sites with thin organic layers, bird vetch (*Vicia*) can establish on thicker moss layers making it better able to invade less severe burns.

Dr. April Melvin, a University of Florida postdoctoral associate, would like to quantify carbon loss from the soil organic layer in thinned and shearbladed sites. She requested help from managers in identifying more fuel treatments done >10 years ago, as well as immediate post-treatment sites. She's also overseeing moss transplant studies using a 1950's fire on Murphy Dome Road near Fairbanks. There are 30 plots designed to see how litter affects moss growth in mid-successional forests, slated for re-measurement in 2013. Relative to carbon storage—birch stands appear to be able to store 2x the carbon of black spruce stands in the **above**-ground biomass, due to increased productivity, while spruce stands store more carbon **subsurface** in the moss and duff layers.

Moss transplant plots experiment (Photo by A.Melvin).

Dr. Ted Schuur, of the University of Florida, one of the principal investigators on the study, reiterated that an important research question is the effect of wildfires on the soil organic layers—not just short-term, but over the longer term--since this is critical in predicting the loss or retention of stored carbon as well as vegetation type. They measured thaw depths at 75 burned sites, in 100 mid- to late-successional stands and 16 managed sites (including the Nenana Ridge experimental fuel treatment). They found that thaw depths in 2004 fires had increased by an average of 16 cm. They are using "thermistor strings" to monitor organic and soil temperatures at different depths, and have a wide network of permafrost sites being monitored using a protocol developed cooperatively with the NPS for their long-term monitoring network.

The author may be reached at rjandt@alaska.edu

Finally, Dr. Hélène Genet, a Research Fellow in the Institute of Arctic Biology at UAF, rolled out the means to tie findings together into a larger picture. She is taking results from studies on fire and organic layer depths and teasing out quantitative relationships to feed the Terrestrial Ecosystem Model (TEM) in order to model future outcomes of changes in fire regime due to climate and to management. They are using data from 178 research sites in 31 fire events from 1983 to 2005. A recent publication in Nature Geoscience by Turetsky et al. 2011 suggests that "ground-layer combustion has accelerated regional carbon losses over the past decade, owing to increases in burn area and late-season burning". Hopefully the TEM will produce estimates of the magnitude of these effects to assist managers with planning and resource conservation.

Next Steps:

Over the remaining two years of the proposal, scientists will be working with agency resource staff to identify management issues and learn about the types of decisions the science findings can inform. Models and tools will be developed to help with decision-making on management activities including fire management and fuel treatments.

●*View a slideshow on the project from the February 2013 Bonanza Creek Long-term Ecological Research Symposium: http://www.lter.uaf.edu/symposium_2013/SAT1100_Melvin_Genet.pdf*

●*Recorded videos from science presentations at the April meeting are posted on our website: http://akfireconsortium.uaf.edu previous events>meetings*.

CITATIONS:

1. Johnstone, JF; FS Chapin III, TN Hollingsworth, MC Mack, V Romanovsky, and M Turetsky. 2010. Fire, climate change, and forest resilience in interior Alaska. Can. J. For. Res. 40: 1302–1312.

2. Boby, LA; Schuur, EAG; Mack, MC; Verbyla, DL; Johnstone, JF. 2010. Quantifying fire severity, carbon, and nitrogen emissions in Alaska's boreal forest. Ecological Applications. 20(6): 1633-1647.

3. Mack, MC.; Bret-Harte, MS; Hollingsworth, TN; Jandt, RR; Schuur, EAG; Shaver, GR; Verbyla, DL. 2011. Carbon loss from an unprecedented Arctic tundra wildfire. Nature 475: 489-492.

4. Turetsky, MR; Kane, ES; Harden, JW; Ottmar, RD; Manies, KL; Hoy, E; Kasischke, ES. 2011. Recent acceleration of biomass burning and carbon losses in Alaskan forests and peatlands. Nature Geoscience 4: 27 – 31.