AFSC Research Brief 2013-4
Nov. 28, 2013

Is Alaska's Boreal Forest Now Crossing a Major Ecological Threshold?[1]

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In this short but powerful paper authors Mann, Rupp, Olson and Duffy look for evidence that Alaska's forests are already responding to changes in fire regime. They use a tool that was developed in lock-step with Alaska fire management agencies called Boreal ALFRESCO. *(Click HERE to view a presentation by Scott Rupp on ALFRESCO)* Using this vegetation-fire model along with stand age and fire map databases, they look forward and backward in time to gain perspective on the short window of forest and forest fire observations in interior Alaska.

How Resilient is the Forest?

Over the past 40 years interior Alaska forests saw:

- **Temperature increase of 1.3°F per decade[2]**
- **Growing season longer by 3 days per decade[3]**
- **Near-surface (1 m) ground temperature increased by 1.3° per decade[4]**

There has been a lot of speculation on the resilience of high-latitude forests in the face of rapid changes in climate. The above changes in physical conditions may not seem all that rapid, until you realize they exceed any warming rate experienced in the past 10,000 years. Evidence is accumulating for temperature stress and temperature thresholds for the main boreal trees. White spruce, for example, appears to grow slower once a critical threshold of 54° F temperature is exceeded in May-July.[5] In 2013, Fairbanks averaged 67° in June and 64° in July, although May was unusually cool. Now scientists are finding that even black spruce may be adversely affected by warming summers (J. Wolken, pers. comm.). Using archived LandSat imagery, Baird *et al*.[6] showed that remotely sensed indices of forest productivity have declined over most of the Interior between 1986 and 2009.

Model Results

Mann *et al*. identify fire as the main and necessary catalyst for changes in forest composition. After all, without some disturbance agent physically modifying the vegetation currently growing at a site, no change can occur because many plant communities possess remarkable inertia to changing climatic conditions. Their results using the ALFRESCO model predict a major increase in annual area burned in Alaska boreal forest beginning about 2010. The longer term consequences of more burned area include further warming of the ground due to removal of shading, thinning of insulating moss layers, and cumulative thinning of soil horizons. However, as every firefighter knows, broadleaf deciduous forest has higher fuel moisture during mid-summer, so why doesn't a negative feedback on burning kick-in as average stand ages decrease? In the ALFRESCO model, the scenarios of future climate are so warm and dry that they overwhelm any such negative feedback due to changing vegetation age. Field experience with fire re-entry into young successional stands in warm dry summers like 2004 and 2013 lends credence to this prediction.

Dr. Scott Rupp takes notes on black spruce forest composition south of Fairbanks (*Photo by R.Jandt).*

A Vision of Future Forests Based on Pre-History

The conclusion is that Alaska's forests may respond to rapid climate warming by shifting back towards an early Holocene state of boreal mixedwoods in which aspen, shrubs, and grasses are more common than spruce. The real "bombshell" is the speed of the transition that the ALFRESCO model predicts: the authors propose that this ecological transition began to speed up about 1990, and may be completed by 2040. As with any forecast, there are caveats. There are potential "holes" in the model including:

- ALFRESCO somewhat insensitive to the ecological inertia imposed by thick organic soil horizons. Only under the most severe drought conditions can burning remove the deepest layers of compacted moss duff. If substantial organic duff remain post-fire, black spruce tends to outcompete other tree species regenerating on these peaty sites.
- ALFRESCO's climate-area burned relationship is based on present conditions. As climate and vegetation cover changes, the relationship between climate and burning that the model uses may no longer hold true—a pitfall for all models which attempt to project future conditions based on today's observations and today's relationships between climate and fire behavior.

For example, what if warmer summers in the next decade lead to many more fires (as predicted), but the higher surface albedos of many early regenerating broadleaf stands causes a cooling of the atmosphere? A recent paper by Rogers et al.[7] points to evidence that the effect of altered forest composition caused by a doubling of annual burn area across Alaska and Canada would cool the surface by 0.4° F during December through May[7]. Regenerating stands in Alaska reflect more heat and light—particularly in winter when snow shows through the bare limbs of dormant hardwood trees and shrubs. This negative temperature feedback amounts to ~5% of projected warming for 2X area burned, and up to 23% for 4X increase in burn area so things are still getting warmer, just not as much.

Clearly, there could be other types of fundamental shifts in weather regimes that we have not yet identified. Still, the glimpse into possible futures of Alaska's boreal forests that the Mann et al. study provides is compelling and important for forest, fire, and wildlife managers to consider.

Fire in boreal mixed woods with litter understory (*Photo by D. Jandt*)

CITATIONS

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6. Baird, RA *et al*. 2012. Browning of the landscape of interior Alaska based on 1986-2009 Landsat sensor NDVI. Can. J. For. Res. 42: 1371-1382.
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[1]This research brief summarizes and discusses the following article:
Mann, DH, TS Rupp, MA Olson and PA Duffy. 2012**.** ***Is Alaska's Boreal Forest Now Crossing a Major Ecological Threshold?*** Arctic, Antarctic, and Alpine Research 44 (3): 319–331. Link to document: http://dx.doi.org/10.1657/1938-4246-44.3.319

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