Wildfire Research to Enhance Ecological and Community Resilience Under Changing Arctic Fire Regimes

March 16-17, 2016
Fairbanks, Alaska

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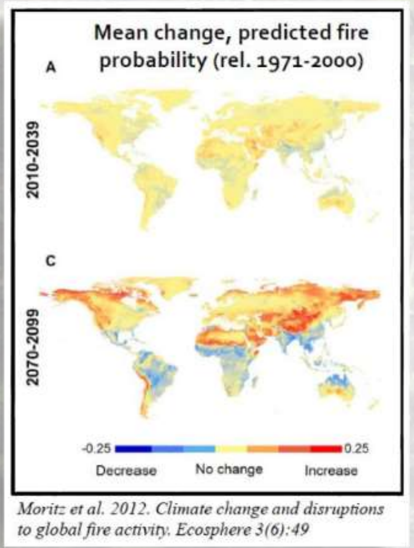
Background:

►Polar amplification of climate warming brings an increase in wildfire.

More frequent or deeper burning could rapidly alter the structure and function of high northern latitude ecosystems[1]. Observational data is mounting to support changes to fire weather (summer temperatures, lightning, snow-free days) leading to more acres burned in Alaska and Canada[2]. In 2015, 5.1M acres (2.1M ha) burned in Alaska, the 2nd largest fire season on record. The Wildfires Collaboration Team (WCT) of the Interagency Arctic Research Policy Commission is interested in identifying potential impacts to communities and human well-being from this increased burning, which models project to more than double in the next 3-5 decades[3].

The WCT is especially interested in identifying areas of rapid, fire and climate-driven ecological change, systems exhibiting resilience or adaptation, and potential fire/land management planning for unwanted impacts that can be assisted with data and research studies.

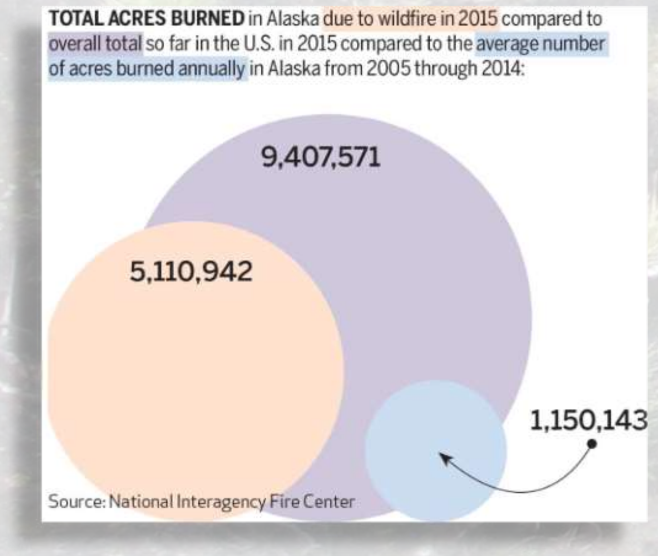


Moritz et al. 2012. Climate change and disruptions to global fire activity. Ecosphere 3(6):49

►Here we illustrate, in brief, four broad areas of where additional observations and research can 'make a difference' for high-latitude ecosystems and communities:

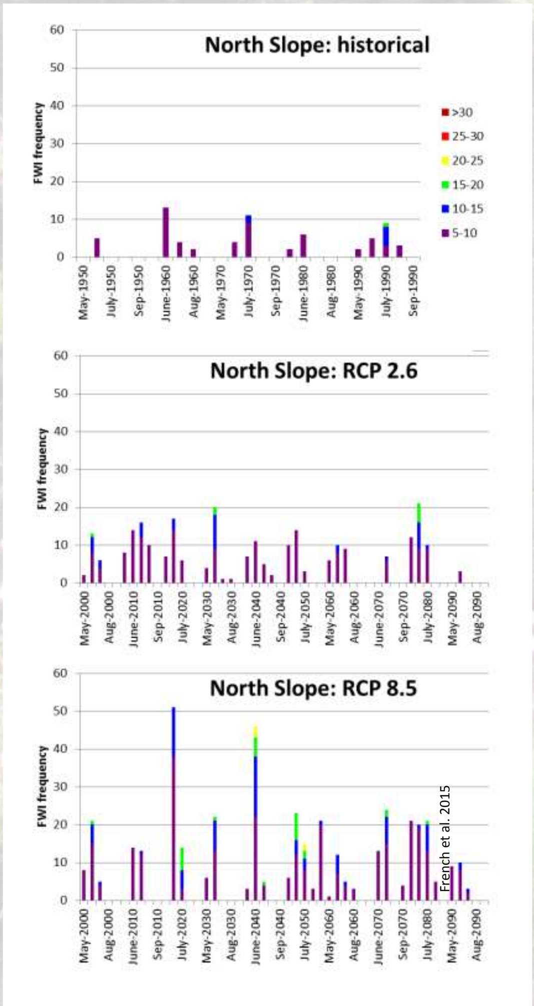
1. Extreme Events:

Knowledge needed to predict and prepare for **extreme event**s: Alaskan agencies charged with fire protection are especially interested in changes in *fire weather indices* projected for the future, in better daily, weekly and seasonal prediction tools, and in the real-time ability to track fuel moisture trends—especially in deep organic layers.

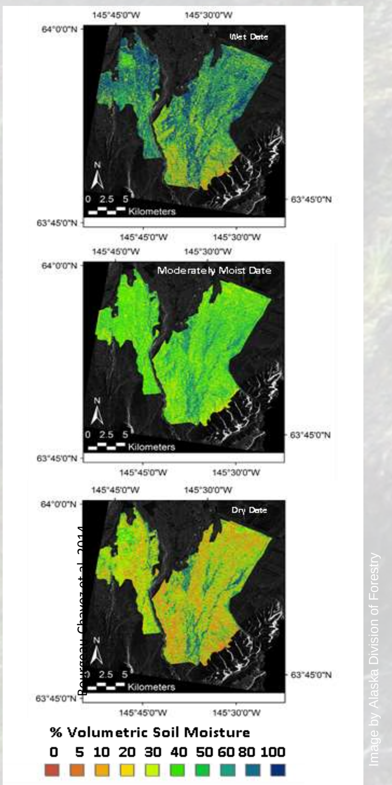


Historic & Future Fires in Alaskan Tundra

- Fire in arctic tundra ecosystems is considered uncommon, but is likely to increase with climate warming and increased human presence.
- Assessment of weather with climate change indicates that tundra areas across Alaska will experience warmer summers and extended periods of drying, increasing the likelihood of larger, more frequent fires[4].



Development of Fuel Moisture Monitoring Capability with Satellite Imaging Radar



Work has been conducted to retrieve fuel moisture from C-band (~5.6 cm wavelength) radar data in boreal black spruce forests. Figures at left show fuel moisture in the low biomass boreal black spruce forests near Delta , Alaska on a wet date (top), moderately wet date (middle), and a dry date (bottom) with RMSE 6.7%. Areas of biomass > 3 kg/m^2 have been omitted since biomass at C-band is confounding the signal. Ongoing work to develop longer wavelength L-band (~24 cm wavelength) radar algorithms for fuel moisture retrieval in forests > 3kg/m^2 are underway.

2. Ecological Impacts:

Quantify sensitivity to increased fire disturbance of the tundra terrestrial eco-hydrological system and implications on fire management and human activities.

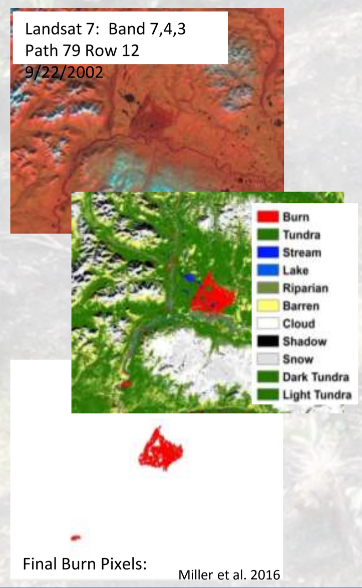
Photo: R. Jandt

Lichens like this *Cladina rangiferina* are very sensitive to fire and take up to 100 years to regenerate cover and biomass.

- What are the ecological impacts of altered fire regimes in the tundra on permafrost, organic soils, water content, and vegetation? How will land management and human activities be affected: Can we anticipate the timing, rate, and magnitude of changes? Can management activities (like changing fire protection levels) make a difference? Annual area burned is expected to double in Alaskan tundra by 2100. Many ecological relationships unique to the high latitudes may play an essential role in global carbon balance and feedback mechanisms as well as having immediate implications for infrastructure.

Detecting and Mapping Tundra Fires:

A Random Forest classifier is used to detect fires in Northern Latitude Landsat scenes. The algorithm is being run on the entire Landsat Archive (1980s to present).



Miller et al. 2016

Detection and mapping of tundra fires has been a low priority due to the expense of detection flights in remote (and sparsely populated) parts of Alaska and Canada. New satellite detection and mapping algorithms are making it possible to map fire disturbance extent to study fire on a landscape scale[4].

Photo: R. Jandt

Post-fire thermokarst exposing a rapidly-melting Pleistocene ice wedge four years after the Anaktuvuk River fire on Alaska's North Slope.

Photo: R. Jandt

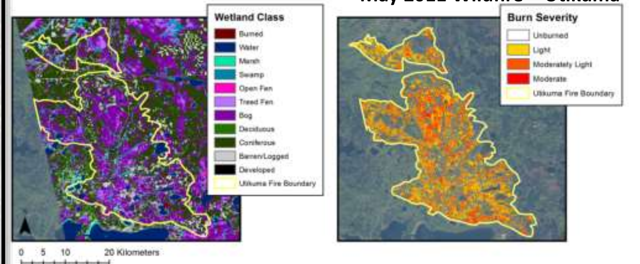
Cloudberry (*Rubus chaemamorus*) recovers relatively rapidly post-fire while crowberry (*Empetrum nigrum*-lower) recovers slowly after tundra fires.

Jack Ahgook Jr. assists ecologist Teresa Hollingsworth assessing post-fire effects on 2007 tundra fire. Caribou compose 70% of year-around subsistence food for Jack's village of Anaktuvuk Pass, so the village is concerned about fire effects on caribou habitat and migration routes.

- Land managers and wildlife managers are especially interested in documenting trends in fire severity, as defined by the deeper combustion of organic layers during fires in boreal forest and tundra, and the resultant permafrost and vegetation response to deep burning. Some of these ecological relationships are unique to the high latitudes and are understudied relative to the number of fire severity studies in more temperate zones yet may play an essential role in global carbon balance and feedback mechanisms as well as having immediate implications for infrastructure.

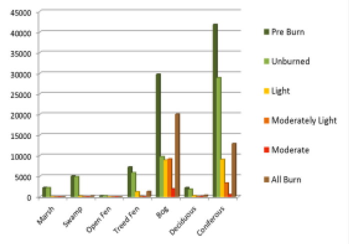
The first widely adopted algorithms for remotely-sensed burn severity were developed in pine forests of the western US (Key and Benson, 2003) and are less than optimal for separating burn severity characteristics in tundra and boreal forest. New research is identifying algorithms that better separate burn severity levels in other soil types, like peatlands.

Burn Severity Mapping of Peat Soils:



Maps of burn severity of peat soils answer regional scale research questions such as :

- do peatlands burn as frequently as uplands?
- how does seasonality affect fuel consumption in peatlands?



- what are the trends in peat consumption and how are they affecting permafrost?

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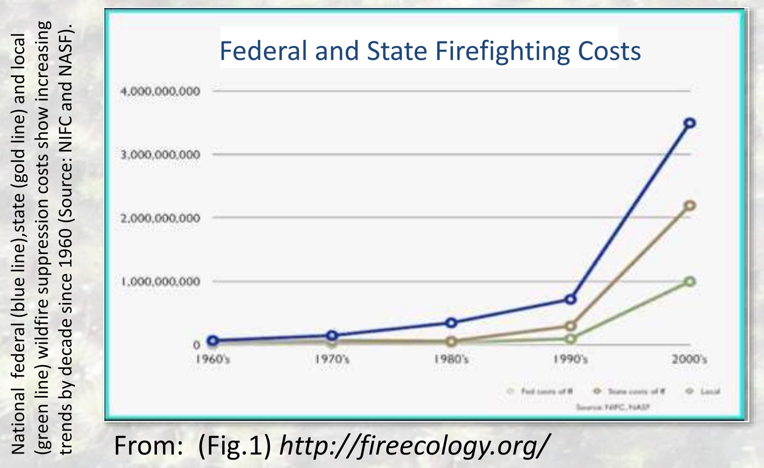
3. Economic Impacts:

What are costs and/or benefits of fire now and what will they be in the future? Are strategies available to mitigate the impacts?

- Economic impacts to residents may be conflicting as income generated through participation in fire fighting helps some, especially rural communities with cash-poor economies, while time away from subsistence activities and direct impacts of fire to subsistence resources may be detrimental.
- Smoke impacts are expected to increase and will have adverse impacts on tourism and air transportation.

Photo: Dale Haggstrom

Smoke from recent large fire seasons especially impacts elders and other at-risk populations.



From: (Fig.1) *http://fireecology.org/ Reduce-Wildfire-Risks-or-Well-Pay-More-for-Fire-Disasters*

- Fire protection in Alaska cost over $250M in 2015: $180M from the State alone. These costs continue to climb[5], and will have an increasing impact on state revenue and management options.

4. Role of Residents & Communities & Policy-Makers:

What are ways to prepare for direct fire threat and increased smoke exposure? What adaptive **vegetation management strategies** are being used? How can arctic residents participate in fire management planning and how may **subsistence** resources and access to those resources change with more fire disturbance?

- Residents have a deep understanding about their local ecosystem and its functions as well as ideas about science needs for the changes occurring in the arctic wildfire system. By sharing this knowledge with researchers and fire management organizations, residents can further the body of knowledge about arctic wildfires and help prioritize research needs.
- Policy-makers decisions will impact investments and successes of (i) early warning systems (that will affect the communities preparedness), as well as (ii) fire fighting/management efforts (that will influence the ecological impacts).

Citations:

[1]Wolken, et al. 2011; Evidence and implications of recent and projected climate change in Alaska's forest ecosystems. Ecosphere 2(11):124.
[2]Hu, et al. Arctic tundra fires: natural variability and responses to climate change. Front Ecol Environ 2015; 13(7): 369–377.
[3]Moritz et al. 2012; Climate change and disruption to global fire activity. Ecosphere 3(6)49.
[3]French, NHF et al. 2015. Fire in arctic tundra of Alaska: past fire activity, future fire potential, and significance for land management and ecology. Intl J of Wildland Fire 24(8):1045-1061.
[4]Loboda, TV et al. 2013; Mapping fire extent and burn severity in Alaskan tussock tundra: An analysis of the spectral response of tundra vegetation to wildland fire. Remote Sensing of Environment, 134: 194-209.
[5]Association of Fire Ecology/IAWF Policy Statement, April 16, 2015; http://fireecology.org/ Reduce-Wildfire-Risks-or-Well-Pay-More-for-Fire-Disasters.

Who are we? IARPC Wildfires collaboration team

"Researching effects of wildfires on local communities in the Arctic"

IARPC Website: *http://www.iarpccollaborations.org*

IARPC COLLABORATIONS
UAF UNIVERSITY OF ALASKA FAIRBANKS
UAF is an AA/EO employer and educational institution.
International Arctic Research Center
Joint Fire Science Program
Alaska Fire Science Consortium

Photo: 2007 Anaktuvuk R. Fire on July 17, 2009 by Chuck Racine