Impacts and Implications of Increased Fire in Tundra Regions of North America

Abstract

The purpose of this project is to assess the impacts of a changing climate on tundra fire and the implications for tundra ecosystem services vulnerable to a changing fire regime. We will investigate the influence of climate change in the Arctic on fire occurrence and fire effects in the tundra ecoregions of North America (NA) and address the question: If fire increases in landscapes where fire is neither currently nor historically of great importance, what impacts will this have on the ecosystem services? Current satellite-based methods for mapping fire at northern latitudes are focused on algorithms tuned to forested landscapes rather than treeless tundra types. Therefore, our current accounting of recent fire for the circumpolar arctic is not complete. Fire regime is also most likely changing, and will be changing quickly since fire is strongly driven by climate. Large, extreme fire events such as the 2007 Anaktuvuk fire have the potential to become more numerous as fire season lengthens and climate conditions become more favorable to fire spread. We intend to connect with current research efforts at the Anaktuvuk site as well as studying fire locations across NA. By looking at fire across the region, the role of fire in shaping ecosystem conditions can be better understood if fire regime changes in Arctic NA.

We plan to improve maps of past fire using remote sensing-based techniques for fire mapping but "tuned" to detect fires in treeless, Arctic landscapes. Surface conditions following fire will be assessed in the field, via literature review, personal experience of the study team, and from remote sensing. We will use the acquired knowledge to drive a fire occurrence model fine-tuned to ecosystem specifics of Arctic NA.. We also plan to apply existing climate models within a framework of fire occurrence modeling to develop future fire occurrence scenarios.

The fire regime information for the past into the future will be used to learn the possible implications of climate change-induced fire regime change. Influences of particular interest are related to impacts on systems specifically vulnerable to climate change and/or disturbance. The factors we will investigate are: 1) changes to surface hydrology; 2) implications for carbon cycling and sequestration; 3) influences on energy balance (greenhouse gases and albedo); and 4) impacts to wildlife land use, such as caribou forage conditions.

How will climate change in the Arctic influence fire occurrence and fire effects in the tundra ecoregions of North America?

If fire increases in landscapes where fire is neither currently nor historically of great importance, what impacts will this have on ecosystem services?

Hypothesis A

Climate changes in the north are causing a fundamental change in fire regime in tundra ecosystems marked by fires of larger size and duration than previously occurred within the last century, leading to increased tundra area burned with higher burn severity.

Objective 1. Characterization of Fire occurrence in Tundra:
- Seasonality
- Area burned
- Burn severity
- Spread rate
- Landscape characteristics influencing fire occurrence

Figure 1: Proposed study region (tundra ecoregions along the Arctic ocean) showing vegetation physiognomy, an indication of fuel type.

The 2007 Anaktuvuk and Kuparuk burns are located in northern Alaska within the *sedge, dwarf shrub, and moss tundra* types.

Objective 2a. Fire Occurrence Modeling in Tundra of North America:
- Canadian Fire Weather Index
- Risk of Ignition
- Potential Fire Behavior

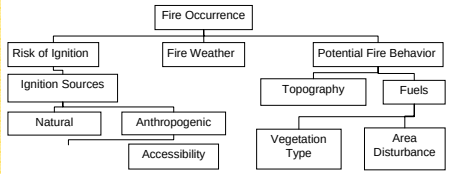

Figure 2: Input parameters for regional fire occurrence model.

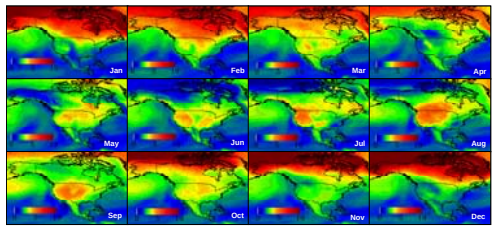

Figure 3: 30-year mean monthly temperature anomalies projected over 2040 - 2069 relative to the 1961-1990 mean of the 20th century for SRES A1B produced by NCAR-CCSM3 model (temperature ranges are stretched between 0 and 10 K with actual values in winter months exceeding 10 K and appearing dark brown).

Objective 2b. Climate-Driven Change in Fire Occurrence Modeling:
- Fire weather change under future scenarios
- Quantified assessment of fire-induced land cover change

***Objective 2* utilizes relationships defined and derived under Objective 1**

Hypothesis B

A change in fire regime will adversely influence ecosystem services, including surface hydrology, carbon sequestration, air quality, and wildlife resources, and enhance the feedback to the climate system through increases in surface albedo and release of greenhouse gas.

Objective 3. Projected Fire Impact on Tundra Ecosystem:
- Surface soil moisture changes
- Pyrogenic emissions of carbon, trace gases, and particulates
- Changes in surface albedo
- Availability of lichen-dominated landscapes to support caribou

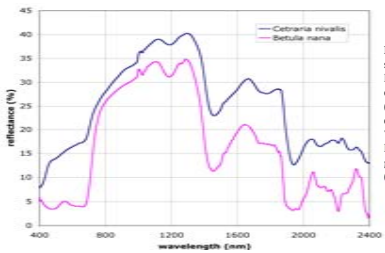

Figure 4: Reflectance spectra of light-colored lichen (C. nivalis) and common shrub vegetation (B. nana). Note difference in the 400 to 700nm region where lichen does not match green vegetation (courtesy of G. Rees).

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