Intensification of wildfire in high latitudes: research priorities to help fire managers

Fire managers in Alaska and Canada believe we are already beginning to feel the intensification of wildfire[1] that has been predicted to come with climate warming. The high latitude boreal forests and tundra are the front lines for climate-driven fire regime changes since they are warming at double the pace of more temperate continental forests (Alaska warmed over 3°F since 1949)[2]. The Alaska 2015 fire season was a wake-up call to the kind of mega-fire seasons possible under warmer conditions. During just one week in June, a barrage of lightning ignited 295 new fires which spread exponentially. Ultimately, 5.1 M acres and about 80 homes were consumed and > $250 M was spent in state/federal firefighting efforts. Alaska exported smoke across Canada and as far as the Atlantic seaboard. Aerial support of tactics and mapping was hampered by thick smoke, as was transportation and tourism. Air quality alert days numbered more than 70. In Canada, over 20 M acres (8.5 M ha) burned in 2014-2015[3]. Together, Alaska and NWT released 216 Tg of stored forest carbon released in 2015/2014 respectively[4], compared to an annual re-deposit rate of around 5 Tg/yr in Alaska's lowland forests[5].

Warmer, and longer, summers are felt to be the primary drivers responsible for doubling multi-million acre fire seasons in Alaska[6] in the last couple decades. Climate model projections indicate parts of the state should be getting relief in the form of increased precipitation, but that has not yet materialized for the fire-prone Interior. It would actually take almost 30% more rainfall to offset the temperature-induced rates of evaporative drying that interior AK now experiences in peak fire season[7]. Year-around average temperature (2015 and 2014 were the two warmest years on record in Alaska) leads to earlier disappearance of snow, more surface albedo heating (off snow-free vegetation and ice-free oceans), degrading permafrost, and surface water drainage. Fire season length (measured as number of snow-free days) is increasing by roughly 5 days/decade in Alaska[8].

Why are the boreal forests and tundra so sensitive to temperature as a fire driver? Much has to do with the forest structure—dense, low-statured, highly flammable conifers underlain by a fast-drying featherbed of mosses and resinous dwarf shrubs: very unlike the downed/woody slash fuelbed models of Ponderosa pine forests in the American west. These forests are highly flammable in their natural state, but climate conditions over the last few thousand years have allowed them to operate as carbon sinks, accumulating tons of organic carbon (actually a third of the world's non-aerosol carbon) in the thick, cold undecomposed peats around their roots[9]. Now that's changed: increases in fire over the past 3 decades have tipped Alaska's forests from a net carbon sink to a source: 3.4% of her carbon reserves lost in the last 30 years (20 years of deposited carbon went up in the smoke of 2015 alone)!

Models of future climate project the number of summer days >70° F—the days that are key to drying out fuelbeds and triggering convective storms—will double in the next two decades and double again by 2100[10]. Canada and Alaska fire scientists expect this to have a large impact on fire danger indices (they share the same fire danger rating system—based on empirical drying models for boreal forest types).

French et al. (2015)[11] analyzed future fire potential for Alaskan tundra ecotones and concluded that most areas will see substantial increase in the number of high-fire-potential days in the next few decades.

Considering that over 80% of Alaska's population resides in the forest or near the wildland interface, this is sobering news. What, if anything, can be done to prepare? Northern fire managers increasingly recognize the fire problem and science and technology needs, yet fire science development funding is limited. It is vital to make the most of every research dollar spent on developing new detecting and monitoring technology, forecasts, better smoke and risk models, and better fuels treatment options to protect communities. Land managers need improved regional understanding of ecological effects of changing forests/fire regimes. For example, the great caribou herds of Alaska and Canada, so important to native subsistence users, may have much to lose with the impacts to their fire-sensitive winter ranges[12]. And, how will fire-induced thermokarsting affect anadromous streams and ice-roads and development infrastructure?

NASA recently launched a 10-year Arctic Boreal Vulnerability Experiment (http://above.nasa.gov/), with a strong fire-science/technology component involving scientists *and stakeholders* from both Alaska and Canada. I emphasize stakeholders because involving the decision makers and regional residents from the beginning in research planning is a proven way to maximize the value of science dollars and to ensure findings and data will be used to inform actions[13]. Along this line, the IARPC Wildfires Collaboration team and AFSC have applied to NASA for a workshop to bring scientists and fire agencies together to highlight research opportunities in wildfire and remote sensing. Needs of managers include boreal-specific fuels maps, fire spread models, forecasts, fire danger indices, monitoring technologies (like sensing real-time subsurface fuel moisture with new airborne and satellite radar technology), fuel treatment techniques, and teasing out the ecological impacts and climate feedback of the changing boreal fire paradigm.

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1 Turetsky et al. 2011; Wolken et al. 2011.

2 https://www.ncdc.noaa.gov/cag/time-series/us/50/00/

3 2014 Canada Report CIFFC

4 Veraverbeke et al. 2015

5 Genet et al. 2013.

6 *Mann et al. 2012. Is Alaska's Boreal Forest Now Crossing a Major Ecological Threshold . AAAR 44(3):319-331.*

7 Flannigan et al. 2013 (research brief).

8 *Liston and Hiemstra, 2011: The Changing Cryosphere: Pan-Arctic Snow Trends (1979–2009). J. Climate **24**:5691–5712.*

9 Jandt, et al. 2013 Research Brief: Climate, Fire, Frost and the Carbon Bank.

10 Walsh, Alaska Climate Research Unit.

11 French, N. H. F., et al. 2015: *Fire in arctic tundra of Alaska: past fire activity, future fire potential, and significance for land management and ecology.* Int. J. Wildland Fire, http://dx.doi.org/10.1071/WF14167.

12 Gustine et al. 2014.

13 https://www.whitehouse.gov/sites/default/files/microsites/ostp/NSTC/sdr_wildfire_st_task_force_final_report.pdf