Abstract

The Yukon-Kuskokwim Delta (YKD) encompasses the southernmost, warmest part of the arctic tundra biome. Ice-rich permafrost currently is widespread and strongly influences terrestrial and aquatic environments. In 2015, the YKD experienced large wildfires across >1,200 km² of permafrost-affected upland tundra. Although the 2015 fire season was exceptional, tundra fire is common in this region with episodes of historical fire circa 1970, 1985, and 1971, offering a natural laboratory for understanding the ecosystem impacts of tundra fire in a discontinuous permafrost region during a period of warming air and ground temperatures. In 2017, we collected field data on vegetation, soils, and burn severity within recent and historical burns and unburned tundra. Using these data we analyzed patterns of correspondence between vegetation species-composition and structure, soil properties, and fire history. We also tested for differences in biophysical properties among the tundra-fire epochs and unburned tundra. Vegetation in unburned tundra was dominated by lichens, whereas burned areas support enhanced cover of shrubs and mosses; however, post-fire shrub cover was composed of the same low-stature species common to unburned tundra and we seldom observed sites colonized by taller, canopy-forming species. Geomorphology and soils were similar in burned and unburned tundra, likely because thick peat layers protected ice-rich permafrost and conferred ecosystem resilience after fire. While this historical perspective suggests that peaty soils will moderate the impact of the 2015 fires, we did observe secondary impacts related to permafrost degradation in circa 2005 fires that were not evident in older burns, such as thaw settlement, increased surface wetness, complex microtopography, and progressive mortality of shrubs. These contrasts represent persistent, rather than successional shifts and suggest that upland ecosystems of the YKD may be less resilient to wildfire disturbance than they were in the past.

Background

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- Pleistocene eolian deposits overlie older portions of the delta and form extensive upland regions with ice-rich permafrost
- Uplands of the YK Delta have one of the most active tundra fire regimes in the Arctic

Ecosystem Dynamics and Succession after Tundra Fire, Yukon-Kuskokwim Delta

What is the Fire History of the YK?

The YKD is best known for its flat, deltoid wetland landscapes. But, uplands are widespread and the region has one of the Arctic’s most active fire regimes. The 2015 fire season was exceptional in the tawny-upland region of Bethel, however, tundra fires were also common in the early 1950s, early 1980s, early 1990s, and mid 2000s. Many basic aspects of the YKD’s fire regime are poorly understood—e.g., wildfires from 1985–1999 are poorly documented because virtually no LandSat data were acquired during this period.

Soil Properties and Thaw Depth

Vegetation Sampling

The short-term effects of fire on tundra vegetation are well understood – but what about long-term impacts? The tawny-upland region is an ideal study area to address this question because species composition and ecological state-factors are heterogeneous across the region. We sampled vegetation in unburned tundra, and tundra that burned circa 1971, 1985, 2005, and 2015. Each plot consisted of 3-5cm transects. We recorded vegetation and abiotic ground cover types at 1-m intervals using a point-intersect approach and summarized per functional type. These training data will also be related to UAV imagery and used to predict the cover of plant functional types across fire-prone uplands of the YKD. We also measured Leaf Area Index (LAI), shrub height, and ecological site-factors.

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UAV Imaging

UAV mapping using a Phantom-4 Pro. UAV imaging provides a quick, efficient means of acquiring high-resolution imagery co-located with field measurements in most weather conditions. The imagery possesses sufficient detail to resolve plant functional types and even individual species. UAV data provide a crucial “infill” scale between field point-intersect data and the 30m LandSat imagery that will be used to model the cover of plant functional types across the tawny-upland region. Patterns of correspondence between abrupt shifts in plant functional type abundance, and known fire perimeters will help to corroborate the findings from the limited number of field plots. We also plan to survey breeding bird populations in the tawny-upland to assess habitat-use in various successional stages after fire.

Key Points

- We studied vegetation, soil, and permafrost properties in recent (2015) and historical tundra fire areas (1971, 1985, 2005). Short-term impacts of tundra fire are well understood, but longer-term impacts are not
- Thick layers of Holocene peat promote resilience to vegetation and "ecosystem-protected" permafrost and reduce the potential for colonization by early successional species
- In the decades after fire, there is a large increase in shrub productivity, but this is not necessarily sustained over time because successional processes favor soil paludification
- Surprisingly, thaw-depths in unburned lichen-rich tundra were shallower than in thick Sphagnum beds; the thermal properties of lichen beds warrant further study
- Unlike older burns, 2005 fire areas are experiencing extensive surface subsidence and shrub mortality, suggesting this ecosystem may be less resilient to fire than in the past

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