Vegetation Composition and Nutrients in a Shifting Tundra Fire Regime

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Introduction:

Anthropogenic climate change has increased average temperature and fire frequency in the Arctic and boreal regions, including the Yukon–Kuskokwim Delta (YKD) of western Alaska. We investigated the impacts of wildfire on plant biomass and nutrient pools in areas that burned in 2015 ("Recent Burn") and in 1972 ("Old Burn"). We hypothesized that immediately after fire plant biomass would decrease, plant-available nutrients would increase, and plants would be relatively more nitrogen (N)-enriched because of the residual nutrient left after burning. We further hypothesized that the ecosystem would recover to baseline biomass levels and stoichiometry within 5 decades following burn.

Methods:

- In 2015, wildfire burned more than twice the area of the YKD than burned in the past 74 years (Figure 4).
- In July 2018, we surveyed four paired 2015 burn and unburned sites and one 1972 burn site.
- In July 2019, we surveyed three areas that included 2015 burn, unburned, and 1972 burn sites.
- Each site consisted of:
  - Three 30 m transects that were 10 m apart, where soil temperature (20 cm), thaw depth, and vegetation percent cover (point intercept method at 1 m intervals) were measured.
  - At the end of each transect, we harvested the biomass in a 900 cm^2 area
  - Biomass was divided into species or functional type, and shrubs were sub-sorted into leaves, stems, and flowers.
  - Plant %C and %N were measured on an elemental analyzer.

Study Area:

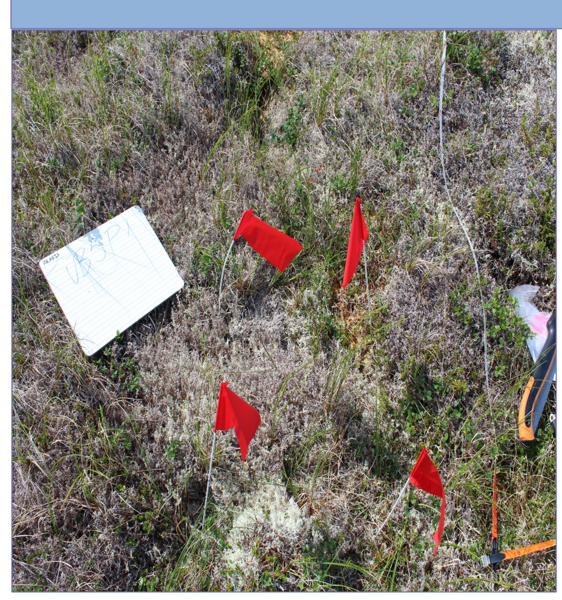


Figure 1. Unburned Plot

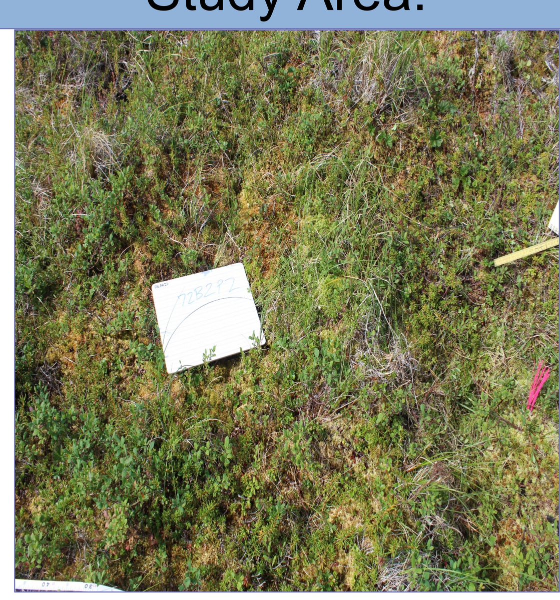


Figure 2. Old Burn Plot

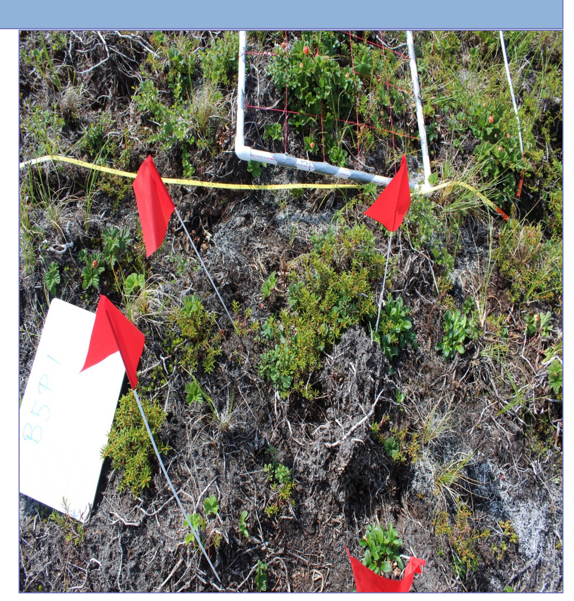


Figure 3. Recent Burn Plot

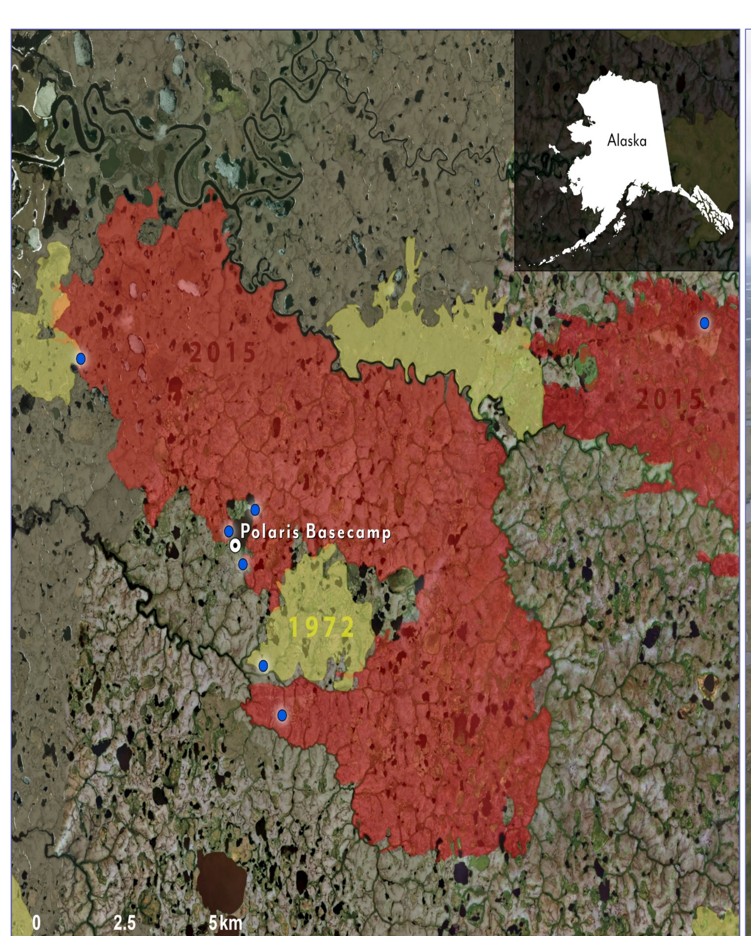


Figure 4. Map of field site

Figure 5. Aerial photo of the YKD

Plots:

Burn: Unburned | Old Burn | Recent Burn

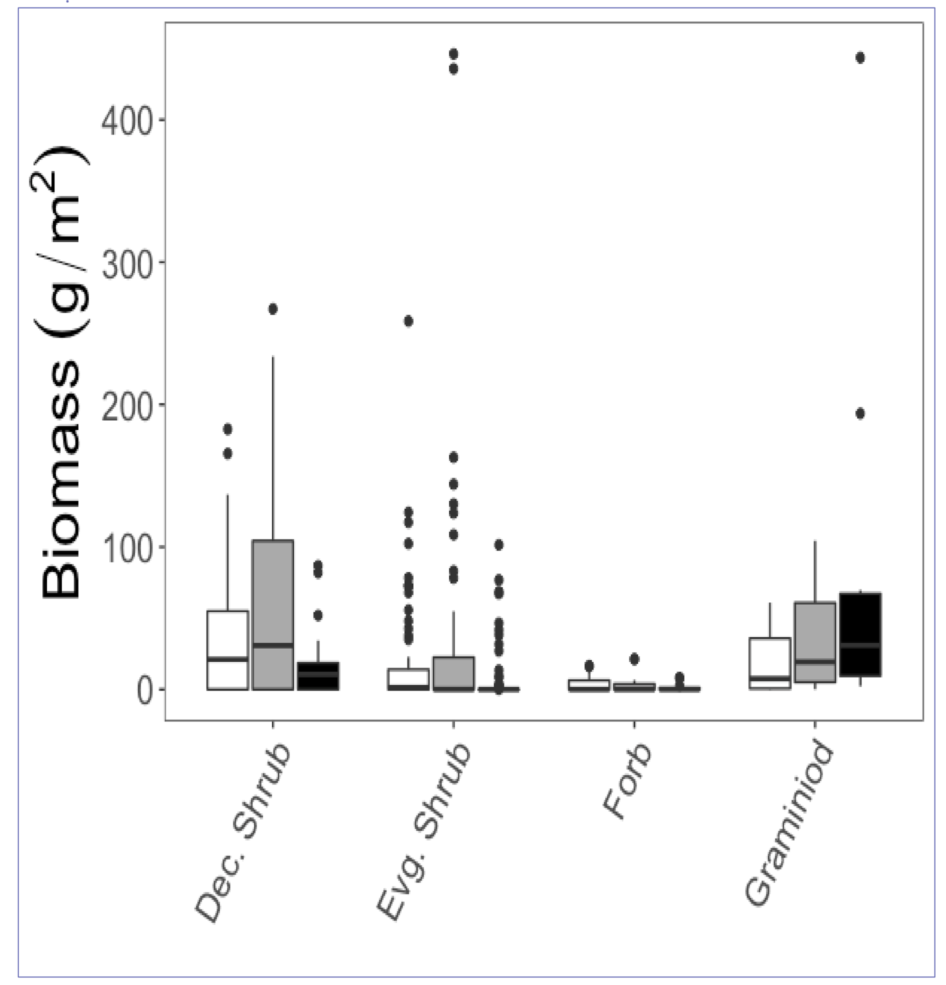


Figure 6. Total vascular plants biomass.

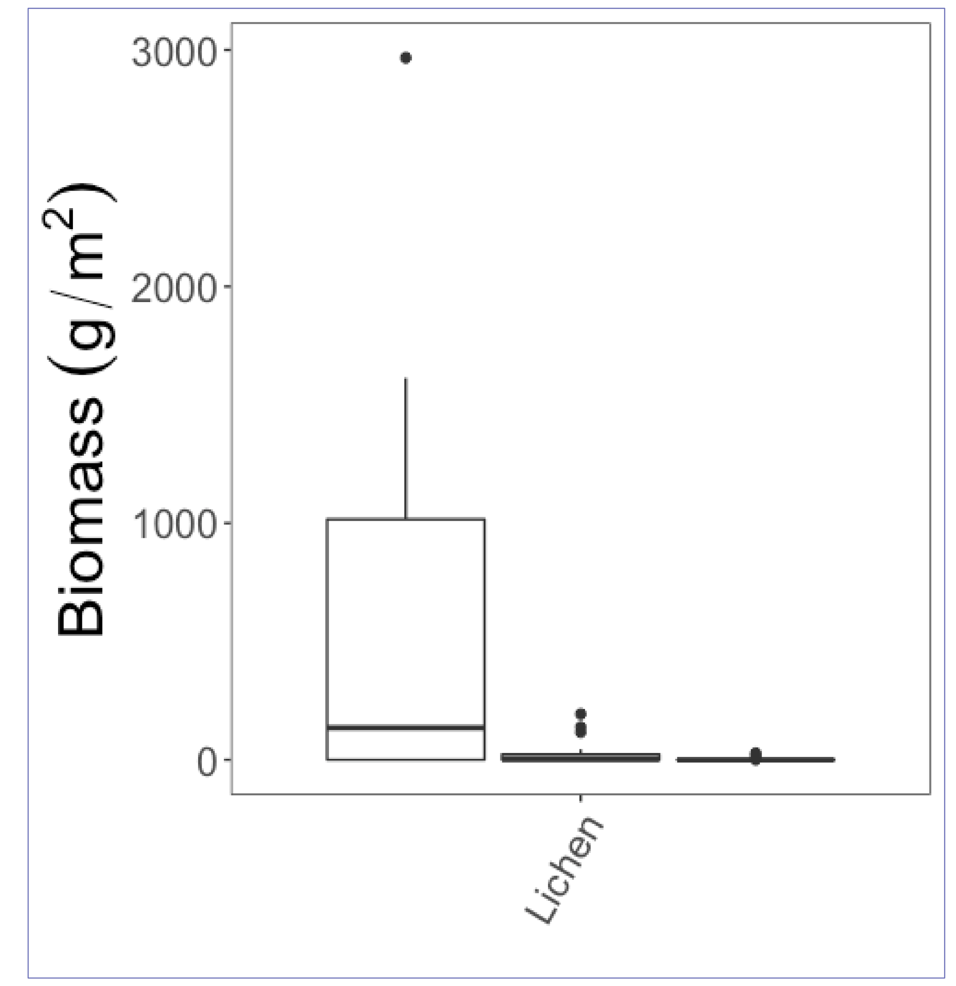


Figure 7. Total lichen biomass.

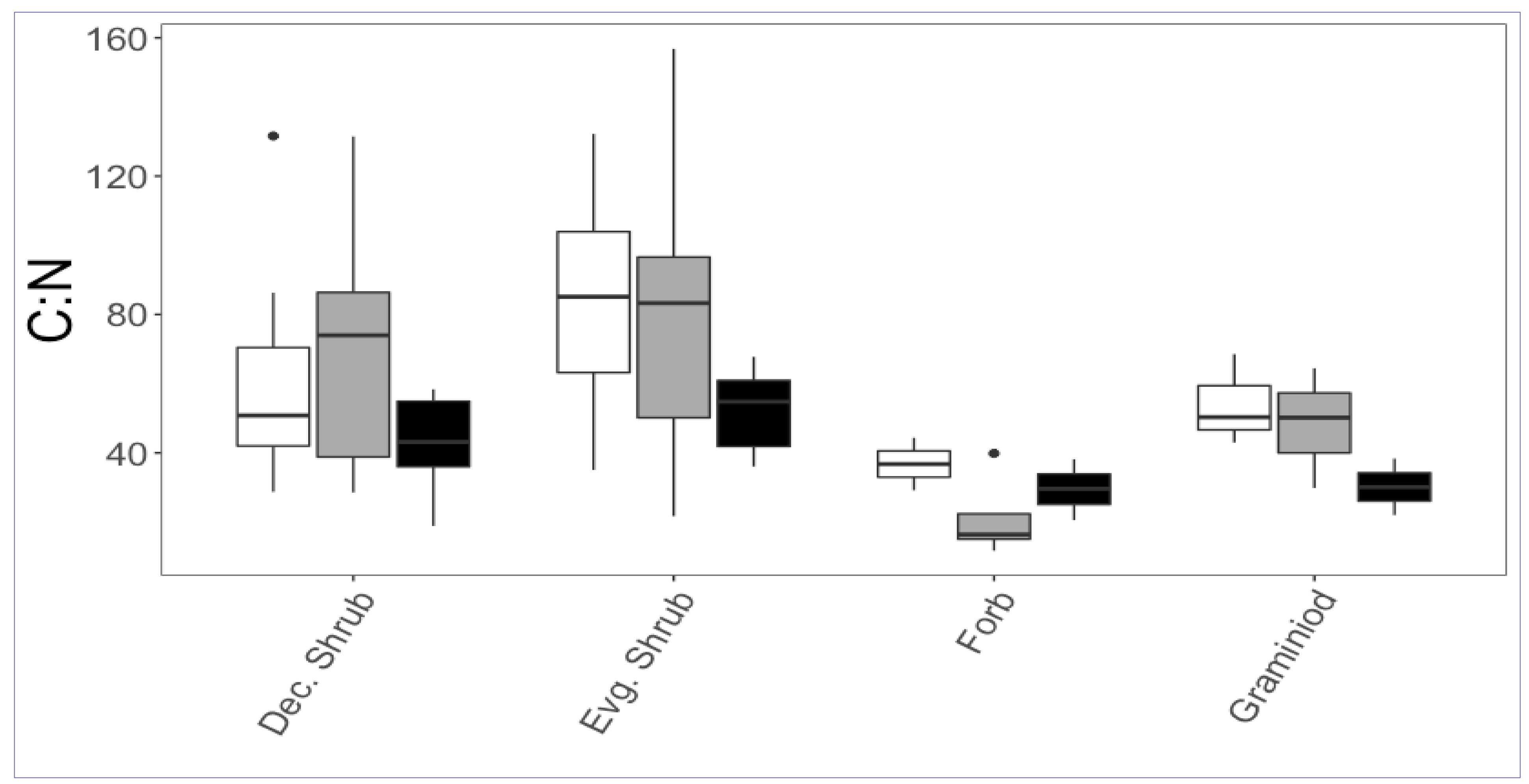


Figure 8. Vascular plant C:N.

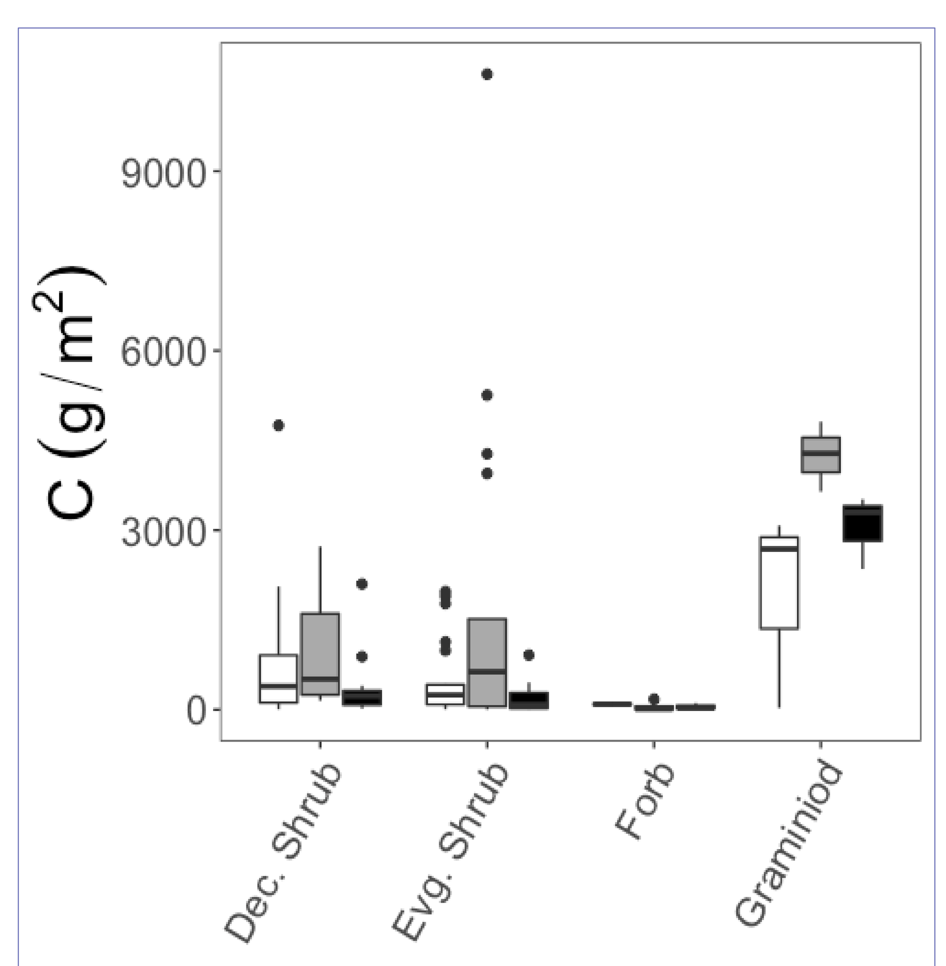


Figure 9. C in biomass for vascular plants.

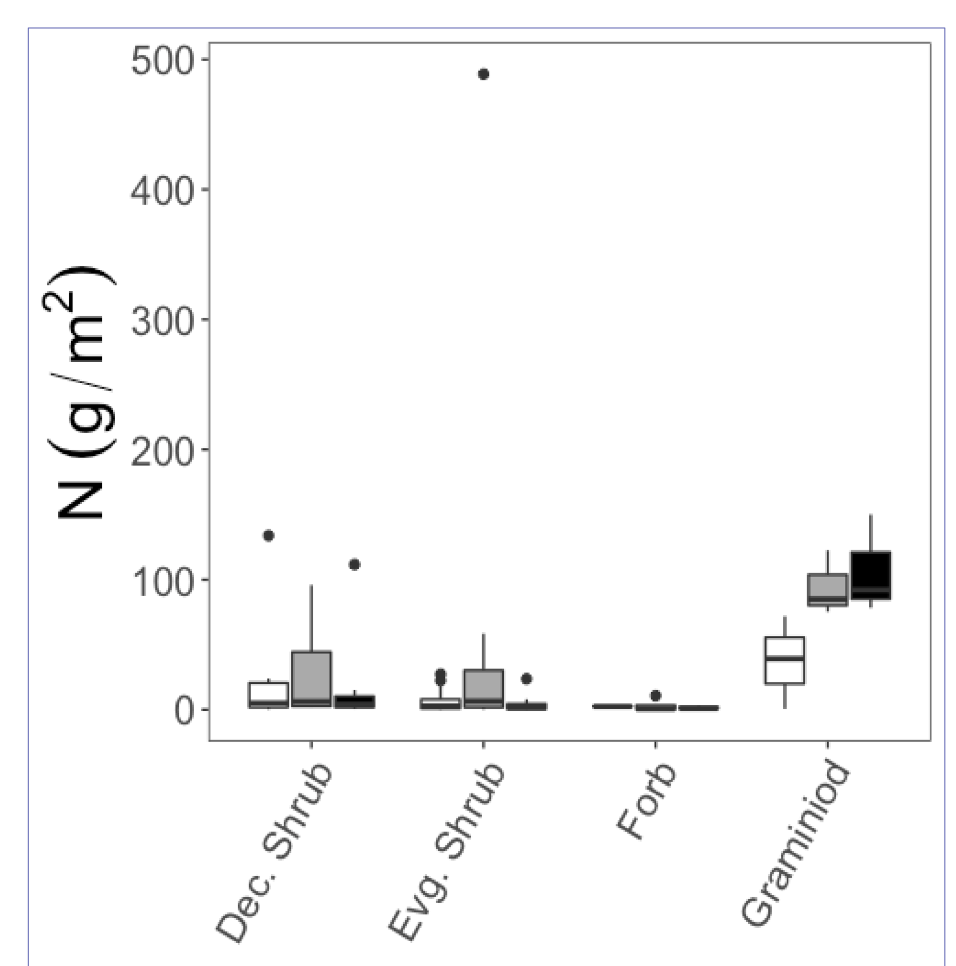
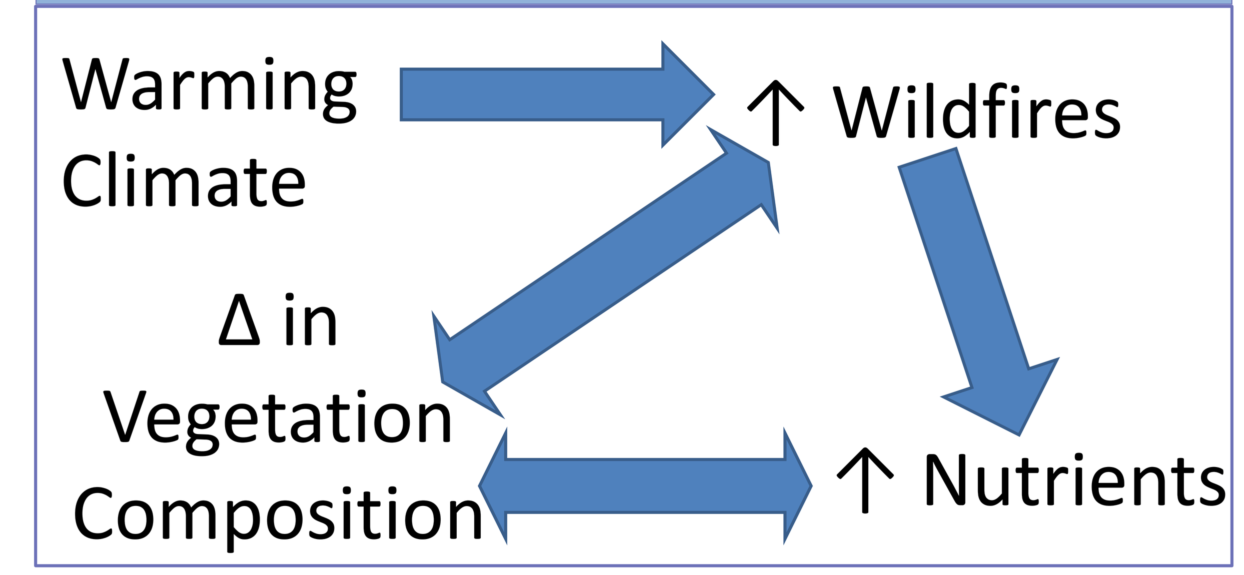


Figure 10. N in biomass for vascular plants.

Conceptual Model:



Conclusion:

- Immediately after fire, plant biomass decreased, with the highest post-fire recovery in deciduous shrubs and graminoids and a significant reduction on lichen.
- In old burn, there was a shift from lichen to vascular plant dominance, demonstrating that fire-driven changes in vegetation composition persisted over decadal time scales.
- This change in vegetation composition may have been driven, in part, by an increase in nutrient availability following fire and by ecological differences among functional groups.
- Immediately after fire, C:N in plant biomass decreased (driven by an increase in %N), but over nearly five decades after fire, plant C:N recovered close to unburned levels (with the exception of forbs).
- Total C and N in aboveground biomass was higher the Old Burn than in unburned, suggesting that fire stimulates increased productivity through N-enrichment and a sustained shift in plant community structure.
- Our findings suggest that wildfire impacts may persist for decades, and that wildfire-driven biogeochemical changes may become more prevalent as fire frequency increases across the Arctic.

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