Fire, successional trajectories, and C pools of boreal forests of interior Alaska

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What is the fate of boreal forest C pools under an intensified fire regime?
Fires will consume more of the C stored in plants and soils.

Positive Feedback to Warming

Increased flux of CO₂ to atmosphere

BUT...Fire can also alter forest regrowth, and changes in plant growth and biomass affect C pools.
Stand dynamics under an intensified fire regime

- Increased fire frequency could decrease stand age.
- Increased fire extent could increase distance to seed source, altering stand composition and structure.
- Increased fire severity could alter soil conditions, germination success, and stand composition and structure.
Cascading Effects of Disturbances

- "Novel" disturbance regimes
- Change environmental conditions
- Reorganize vegetation communities
- Shift ecosystem function
If increased fire severity leads to a shift in canopy dominance from black spruce to greater deciduous cover, what are the implications for C dynamics?
Approach

Quantify C pools within mid-successional stands representing a compositional gradient

Black spruce

Deciduous (aspen or birch)
Site Selection

Intermediate-aged fires
(20 to 59-yr old)
Site Selection

Evidence of previous fire

Signs of potential black spruce origination

Upland sites of intermediate quality where shift is most likely
Intermediate-aged stands (20 to 59-yr old)
Methods

- **Stand structure**: density, basal area, composition, leaf area index
- **Aboveground tree/large shrub biomass, ANPP, and snag biomass**: stand inventory and allometric equations
- **Downed woody debris**: Line-intercept method
- **Understory composition**: Grid-intercept
- **Stand age**: ring counts
- **Organic layer and upper mineral soil carbon pools**: cores
How well can we explain C pools based on deciduous IV and two other potentially important explanatory variables (years since fire and density)?
Aboveground biomass of trees/large shrubs

- 64% of variability explained by deciduous IV and years since fire.
- Similar trends in ANPP (48% explained).
Snag Biomass

- 13% of variability explained by years since fire

- 49% of variability explained by both years since fire, deciduous IV, and their interaction.
Downed Woody Debris Biomass

- 29% of variability explained by years since fire and density.
BUT...
What about differences due to forest type?
How does one define forest type?

Sometimes a stand is clearly dominated by a single species, but in reality, most stands are mixed.

1) Community analyses?

2) Grouping by Deciduous IV?

3) Proportion of stand biomass?
Aboveground biomass by forest type

- Black spruce
- Paper birch + black spruce
- Aspen + black spruce
- Aspen
- Paper birch

Years since fire:
- 20
- 25
- 30
- 35
- 40
- 45
- 50
- 55

Aboveground biomass (g m\(^{-2}\)):
- 0
- 5000
- 10000
- 15000

Graph showing the aboveground biomass for different forest types over the years since a fire event.
ANPP by forest type
ANPP\textsubscript{tree} by forest type

ANPP\textsubscript{tree} (g m\(^{-2}\) yr\(^{-1}\))

- Black spruce
- Paper birch + black spruce
- Aspen + black spruce
- Aspen
- Paper birch

Years since fire
20 25 30 35 40 45 50 55
Summary

• Both aboveground biomass and ANPP of trees/large shrubs increased with increasing deciduous IV.

• These increases were inextricably linked to increases due to years since fire.

• There was no effect of deciduous IV on downed woody debris or evergreen snag biomass, which varied mostly with years since fire.

• Deciduous snag biomass increased with increasing deciduous IV, but only in older stands.

• Black spruce stands accumulated and stored less biomass than all other stand types.
Ongoing Work

• Will variations in soil C pools compensate for differences in aboveground C pools?

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Ongoing Work

- Are changes in C pools associated with shift in canopy composition sufficient to offset C lost to the atmosphere during the fire disturbance?
- What is the fate of C pools as mixed and deciduous stands mature?
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Questions?