Introduction outline

General – similar to nserc? Very broad carbon importance

what else to talk about?

- carbon cycle

- boreal forest

The boreal forest

The Boreal Forest is the largest biome on Earth, forming a circumpolar belt between 50˚ and 70˚ N (Hagner, 1999). \*\*add sentence about carbon storage\*\* It contains 30 % of the world’s forested area (International Boreal Forest Research Association, n.d.) and is dominated by cold-tolerant species, mostly conifers with interspersed broadleaf trees. This large stock of above ground vegetation is one reason the Boreal Forest has the potential to act as a large carbon sink (Pan et al., 2011). Another portion of the boreal forest that contributes to its large potential to store carbon is below ground: in the soil. Slow decomposition of organic matter, caused by low temperatures and high acidity, leads to organic carbon accumulation in the soil (Deluca & Boisvenue, 2012). Soil organic carbon is approximately 40% of total carbon in Canada’s boreal forest (Kurz et al., 2013).

Canada contains about a third of the world's boreal forests (Canada, 2013), with 7 % of that found in Newfoundland (~ 2 % of global Boreal Forest; “Provincial and Territorial Forest Facts” n.d.). In fact, over 90% of Newfoundland is covered by boreal forest. And, in Newfoundland’s national parks, Gros Morne and Terra Nova National Parks, over 50% of the terrestrial landscape is classified as boreal forest (Baldwin et al., 2020). The Newfoundland boreal forest is dominated by balsam fir and black spruce and has low levels of mixed wood and other tree types (*Forest Inventory Program*, 2022). While about three-quarters of the terrestrial portion of the province’s national parks is forested, about a fifth is classified as shrubland, where over 10% of the land is vegetated but under 30% is covered by trees cite Glance30. These areas could lack trees for several reasons: they are swamp and have standing water, elevation or wind is too high, or a disturbance has killed or removed the trees.

Unfortunately, under anthropogenic influence, boreal forests in Newfoundland have come under increased pressure from disturbances which may decrease carbon storage (Dymond et al., 2010; Leroux et al., 2020). The increased pressure has partly resulted from past forest management, which altered the distribution and intensity of key disturbances such as defoliating insects, forest fires, and ungulate herbivory. Spruce budworm outbreaks are now more widespread and severe (Morin et al., 2021), forest fire regimes in North America are exceeding long-term historical rates while being suppressed as frequent, low disturbance events (Kelly et al., 2013; Nuttle et al., 2013), and moose populations in eastern balsam fir forests have become some of the densest in the world (Nosko et al., 2020). It is now understood that these alterations to disturbances can have interacting, negative implications, decreasing the amount of carbon stored by boreal forests (Bergeron & Leduc, 1998; Dymond et al., 2010; Leroux et al., 2020).

The carbon cycle:

From proposal:

The Boreal Forest can store a vast amount of carbon and has potential to act as a carbon sink (pan, 2011). Carbon can be stored in live or dead biomass found above or below ground, and in organic and inorganic matter in soil. Sequestration of carbon into the boreal system happens through photosynthesis, creating live biomass in the form of vegetation, then moves between pools via geochemical, microbial, botanical, and animal mediated processes. Finally, carbon returns to the atmosphere through heterotrophic and autotrophic respiration, and combustion.

Disturbances

Forest clearing events

- insect effects

General info: general impact of insects on forest

How that impacts carbon storage/cycle

How they are being managed worldwide

In the park

Which insects present

How they are impacting the forest \*cite Rachael’s thesis

Possible management techniques/what the parks opted not to do

- forest fires

General info:

How that impacts carbon storage/cycle

Forest fires reset succession

Important for many ecosystems

But – also releases a lot of carbon

And regime is changing -> more carbon and more damage

In the park

TN only

How it has progressed

Recent history

Prescribed burns

- logging

General info

How that impacts carbon storage/cycle

Important Canadian resource

Claims to lock carbon into solid material \*but often not really

However, does limit carbon within the ecosystem being taken from

In the park

Personal harvest allowed in GM

And recovery of insect killed wood

Not extensive but concentrated

Moose

General info

A large herbivor with range ?

Many effects on the carbon cycle through herbivory, trampling, excretion

They selectively eat certain vegetation

In the park

Non native to Newfoundland and record breaking numbers

When did hunt begin in TN

Just recently beginning hunt in GM

Moose after forest clearing event

Believed to slow or halt succession

Thus limiting carbon storage

Goals

In to specific chapter introductions:

Chapter 2:

Boreal forest ability to store carbon

Alteration of key disturbances affects forest characteristics -> leads to changes in carbon

\*effect on soil?

Leaching to streams – see Hannah’s paper

The merits of being able to predict carbon locally with broadly available information

Goal of park to monitor carbon – good to understand what is there now

Hypotheses \*these can go in the chapter 2 and 3 introductions

For predicting in space – what environmental variables will have an impact and why?

Predominantly forest aspects that will play a role \*soil carbon not substantially impacted by disturbances

* Height, canopy cover, species composition, age -> trees are a major part of carbon storage in the boreal forest, so their size and abundance will likely correlated highly with carbon
* Major difference between cleared areas and mature forest is the prevelance of large trees -> represented by forest characteristics
* Species composition -> impact how much herbivory and therefore carbon

topogrpahy may impact carbon through their impact on forest characteristics

* + what can grow where
  + differences in rate of growth (climate mediated)
    - wind, temp, sun exposure
  + what can reach to eat – refuge from herbivory if too steep or high elevation
* or explicitly
  + Differences in climate -> different rates of cycling
  + Horizontal movement of carbon (litter, runoff, etc)

Chapter 3:

Interaction between herbivory and forest clearing events

And Implications for carbon

From proposal:

Recently, the role of animals in the carbon cycle (zoogeochemistry) has received more interest. Both the direct (e.g. consumption and excretion) and indirect (e.g. changing litter quality and soil structure) impacts of animals on carbon storage have gained recognition (Schmitz *et al.*, 2018). The impacts of animal mediated disturbance on the carbon cycle are of particular interest in Newfoundland. SBW outbreaks and moose herbivory can have large impacts on forest structure and, therefore, carbon storage (Leroux *et al.*, 2021).

Why combine mechanistic with process-based

Hypothesis:

For relationship between moose and forest composition after forest clearing event

Because think moose keep forest from regenerating: especially through selective herbivory

Moose herbivory after forest clearing events may be a driving force behind the patterns of carbon storage in national parks

\*see conceptual figure