First, I have to make it clear that this work is based on Professor David Wardle’s work. I have mentioned potential collaboration with Ice project people to him, and he was positive.

**Carbon sequestration dynamics in boreal forests in response to natural and human-induced disturbance**

The interest in ecosystems’ uptake and release of carbon in the form of carbon dioxide has increased over the past couple of decades due to human-induced accelerated emissions of carbon from fossil fuel combustion and subsequent influences on global climate. In ecological research, a heightened interest is in part due to the presumed ability to mitigate climate change by increasing ecosystems’ ability to sequester atmospheric carbon. The boreal forest, the world’s largest forest biome, sequesters huge amounts of carbon, above- but primarily belowground, and is therefore a very important driver of the global carbon cycle. It is well known that forest fires are a major driver of the carbon balance in boreal forests, but recent research indicate that plant community composition is of equal importance. In other words, as plant community compositions driven by temporal successions differ in their ability to take up and release carbon, boreal forest ecosystems’ ability to sequester carbon changes with the age of the system. In other words, young, early-successional forests grow fast and store carbon at a high rate, but at the same time they produce plant litter that decompose at an even faster rate, leading to a low net gain in carbon storage, or even a net release of carbon. In contrast, older systems fix carbon at a lower rate, but also release carbon through decomposition much slower than younger systems, resulting in a build up of carbon - primarily belowground.

Protecting boreal forest from forest fires has probably led to increased total carbon storage in these systems, but boreal forest management (i.e. clear cutting and subsequent ground preparations), promoting early successional, fast growing species has likely had adverse effects on forest carbon storage - especially if belowground carbon is taken into account. Both natural and managed forests experience dynamics in forest age and thus in ability sequester carbon.

In an island system in northern Sweden, there are 30 boreal-forested islands of different sizes. These islands that have been extensively studied over the past 15 years (Prof. David Wardle) are differently affected by forest fires due to their different sizes. Small islands are rarely struck by lightning, therefore burn rarely, and are thus of old age. Large islands are more often struck by lightning and have therefore burned more frequently than small islands, and are thus of much younger age. These young islands are productive and contain early-successional species that grow fast, and therefore store carbon at a high rate in the aboveground biomass. However, these species produce litter that decompose fast and therefore release carbon at a high rate, leading to relatively low amounts of carbon stored belowground. As the frequencies of forest fires decrease with decreasing island size, the plant composition changes to late-successional, more slow-growing species that produce slow-decomposing litter leading to a greater uptake than release of carbon from the system, and a continuous build-up of carbon in the belowground system. In a recently published study (Jonsson & Wardle, Biology Letters 2010), it was shown that the succession of plant species was as important as forest fires in explaining the amount of carbon stored in these boreal forests. Further, this study (along with previously published results from these islands) shows that the majority of carbon (up to 94%) is stored belowground.
Primary productivity and litter decomposition showed no detectable effect on carbon storage.

Few large-scale systems, if any, are as well studied as the island system in northern Sweden. Practically all potential drivers of carbon sequestration in these boreal forests have been studied in detail over the past 15 years on these islands. Hence, this system is the ideal model system for obtaining data that is suitable for extrapolation and modeling of carbon balances on even larger scales. In particular, it would be very interesting to extrapolate the data on larger scales and ask the questions:

1. What do the boreal forest carbon dynamics look like (based on the island data).
2. What happens with carbon storage in the boreal forest biome in the event of changes forest fire frequencies (e.g. climate-change induced lightning ignited forest fires)?
3. What happens with carbon storage in the boreal forest biome in the event of changes plant community composition due to forest management, such as clear cutting, reforestation, and forest fertilization?
4. Thus, is it possible to model carbon storage dynamics in boreal forests that experience different frequencies of natural and human-induced disturbances?

My uninformed idea is that it would potentially be possible to treat fire- or management-struck regions of the boreal forest as ‘sub-populations’ in the forest landscape and thus utilize some kind of metapopulation theory on the carbon balance/dynamics, in which ‘carbon populations’ die (due to forest fire or management) or grow (due to old age). Most (all?) data is available to model this and extrapolate it on a larger scale in a dynamic ecosystem model. Details, however, need to be addressed, and I am not the right person to suggest how this can be done.