QuickNotes

Science summaries from fRI Research

Introducing: Soil carbon stocks in forests recovering from mountain pine beetle outbreak: a possible C sink?

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Carbon source or sink?

Owing to the loss of carbon uptake and increased emissions from decomposing trees, pine forests killed by mountain pine beetle were predicted to shift from carbon sinks to sources. Since these projections were made, however, our knowledge on the processes influencing carbon fluxes among soils, plants, and the atmosphere has been transformed. While long believed to increase soil carbon stocks through litter input, we now understand that living trees can reduce these stocks through their interactions with microbes that mine nutrients from soils, in a process known as 'priming'. Importantly, most carbon in boreal forests is contained in soils, thus processes that destabilize this pool will have pronounced effects on carbon sequestration, a critical ecosystem service. Although dead trees cannot photosynthesize, they also no longer fuel the activity of microbes mining nutrients from soils. In consequence, the widespread mortality of pines may indirectly increase soil carbon stocks. Furthermore, the replacement of pines in forests disturbed by mountain pine beetle with shrubs and herbs may amplify this increase in soil carbon stocks.

The importance of plant 'mycorrhizal type' and carbon cycling

Plants of the boreal forest form mycorrhizas with different kinds of fungi and these fungi have different effects on carbon cycling in terrestrial ecosystems. Roots of pines are colonized by ectomycorrhizal fungi, microbes that mine nutrients from soil organic matter. The return on investing in ectomycorrhizal fungi is typically more biomass for pines. To mine nutrients, fungi respire CO_2, pulling C from soils and transferring it to the atmosphere. Thus, there can

Federal-Provincial MPB Research Partnership

Mountain Pine Beetle remains a severe threat to Alberta's pine forests despite the province making positive progress in controlling its spread within the province and reducing the risk to the rest of Canada.

Natural Resources Canada and Alberta Agriculture and Forestry have provided funding to a suite of projects with the goals of limiting the spread of Mountain Pine Beetle and mitigating damages where it has already invaded.

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be a negative relationship between ectomycorrhizal tree growth and soil carbon stocks. Roots of most plants forming the understory of boreal forests are colonized by arbuscular mycorrhizal (AM) fungi. Opposite of ectomycorrhizal fungi, these fungi scavenge nutrients and do not degrade organic matter. In the absence of priming and owing to differences in rhizodeposition, carbon from AM plants tends to flow into long-term carbon pools in soils. In short, ectomycorrhizal plants can reduce soil carbon accrual and AM plants may promote it.

Switching of mycorrhizal types following mountain pine beetle outbreak

In many areas across Alberta, AM shrubs and forbs are succeeding the mature pine trees killed by mountain pine beetle. On one hand, poor pine regeneration produces less timber in the future. And while interventions may restore some of these sites to pine, some may be beyond recovery. From a timber perspective, these sites are deemed a loss but from a broader ecosystem services perspective, they may have value to our landscape. Specifically, the replacement of ectomycorrhizal pines by AM shrubs and forbs may be an overlooked and yet-to-be quantified carbon sink.

Objectives

The objective of this research is to compare soil carbon stocks in stands disturbed by mountain pine beetle with those in intact lodgepole pine stands to test the hypothesis that the mycorrhizal type of the dominant vegetation influences carbon cycling.

Expected outcomes

We will quantify soil carbon stocks and, in collaboration with the Northern Forestry Centre/Canadian Forest Service, fill a critical knowledge gap in the soils component of the Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3). This model is an aspatial, stand- and landscape-level framework that simulates the dynamics of forest carbon stocks. However, the understanding of carbon cycling following disturbance such as mountain pine beetle, for example, is still incomplete. Therefore, research into the role of mycorrhizal fungi and how the mycorrhizal community changes as the forest composition changes following disturbance, is critical to build knowledge of carbon stocks.

Implications for Land Management

Most carbon in boreal forests is stored in soils, not trees. Processes that increase soil carbon stocks may partly offset the reduced carbon uptake of pine forests killed by mountain pine beetle. Investigating differences in how stands sequester carbon is an important step in managing landscapes for multiple ecosystem services. In addition to the widespread mortality of pine, other dominant ectomycorrhizal trees, such as aspen, are also being replaced by arbuscular mycorrhizal shrubs and forbs in some parts of the province. Thus, the research will have broad relevance to assessing the consequences of changes in forest composition on soil carbon stocks.

Expected Social, Economic, and Ecological Value

This research is relevant to forestry operations, risk assessment and/or policy development because it can help inform decisions on triaging stands for rehabilitation. Moreover, by further understanding the underlying ecological processes, this research may develop management instruments to sustain and possibly increase the ecosystem services provided by forest landscapes. We will also fill in knowledge gaps of modelling forest carbon stocks in response to disturbance.

Expected date of completion of the project

December 2023

For more information on this project, contact Dr. Justine Karst at karst@ualberta.ca