Title: A Pan-Canadian Assessment of a Functional Complex Network Approach to Forest Management

Subtitle: Fostering social acceptability and forest resilience to global change through functional diversity and connectivity

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Current Challenge

Global changes threaten the adaptability, resilience, and sustainability of Canada's forests. They also increase the intensity, frequency, and duration of natural disturbances (e.g., fire, insect outbreaks, windthrow), which contributes to the fragmentation of the forest landscape, and the arrival of new exotic and/or invasive pests and diseases. Global changes, therefore, pose major threats to the capacity of our forests to meet our socioeconomic needs while still maintaining essential ecosystem services (e.g., carbon storage, clean water, wildlife habitat, recreation, wood and pulp). Yet forest management still largely focuses on sustained yield and volume maximization, an approach based on the predictability of forest dynamics and past conditions. In this context, there is an urgent need for developing new forest management approaches that increase forest resilience to the unpredictability of global change and its potentially devastating impacts.

Proposed Solution - Functional Complex Network (FCN) Approach

Here, we propose the Functional Complex Network (FCN) approach (Figure 1). It seeks to optimize both the diversity of tree species with specific ecological traits such as wood density, rooting depth, bark thickness, drought and shade tolerance, seed weight and dispersal types, type of mycorrhizae, etc. (called functional diversity) and the connectivity among stands in terms of seed propagation from a wide variety of tree species (called functional connectivity) to promote adaptability and resilience at stand and landscape scales. Most adaptation strategies currently being put forward (e.g., Climate-Smart Forestry) tend to focus on adapting forests by selecting a few key tree species well-adapted to projected changes in climate. In doing so, they offer interesting approaches to increasing the resistance and resilience of forests to known future climate change conditions. Such an approach, however, fails to consider the high uncertainty associated with future climate change and many other potential stressors such as invasive pests and insects that could interact with climate change to create highly uncertain future conditions. By favouring stands with a diversity of tree species having very different ecological traits we (1) reduce risks of having many tree species affected by the same stressor, and (2) improve the vitality of the forest due to complementarity, i.e., the reduction in competition among tree species having different resource requirement. Furthermore, by favouring a landscape with high functional connectivity, we greatly increase the ability of the forest to reorganise itself efficiently following various disturbances, making the forest highly resilient to unknown future conditions. The FCN approach intends to shift the focus from yield to functional diversity and connectivity, making future conditions' unpredictability central to its vision. It aims at cost-efficiently maintaining sustainable harvesting levels while maximizing the adaptability and resilience of our forests.

Testing FCN Across Canada's Managed Forest

Nationwide testing of the application of the Functional Complex Network is about to kick off across Canada's managed forests (Figure). The project has amounted to an impressive partnership that includes heavy involvement of the forest industry, First Nations, provincial government agencies, non-governmental organizations, and over 50 academic and government researchers collaborators. The project is centered around six integrated themes (Figure 2) that will be tested across 20 forest management areas across Canada, including 6 in Ontario (Kenora, Wabigoon, Pic, White River, Spanish, Temagami, and Haliburton). **Research Themes:** *Theme 1* will evaluate the current functional diversity and vulnerability of Canada's forests. *Theme 2* will then focus on identifying groups of suitable tree species to be promoted within the regions deemed most susceptible (in Theme 1), while considering climate change and future disturbance regimes. *Theme 3* will represent current forests as a FCN for each forest management areas, effectively creating maps of functional diversity and connectivity for each management area developed from on-the-ground data from our partners. *Theme 4* will then simulate three different forest management scenarios: (i) business as usual (status quo), (ii) climate-smart forestry, and (iii) FCN, each then being tested under a suite of climate and forest disturbance scenarios. *Theme 5* will evaluate the socioeconomic considerations of this new forestry approach, focusing on the financial implications, social acceptability, and possible modifications required for Canadian forestry regulations and standards to adapt to the FCN approach. Finally, *Theme 6* will develop and test alternative silvicultural field trials and multi-species plantations, focusing on the most promising silvicultural approaches implemented elsewhere and adjusting them to results from previous themes.

With this project, we will develop an innovative forest management approach to mitigate and adapt our forests to global changes. By developing and testing our methodologies in close collaboration with industry across Canada, we aim to provide managers and practitioners across the country with guides, tools, and simulation models that can be used to further test novel conditions and adapt management practices to the known and unknown conditions of tomorrow.

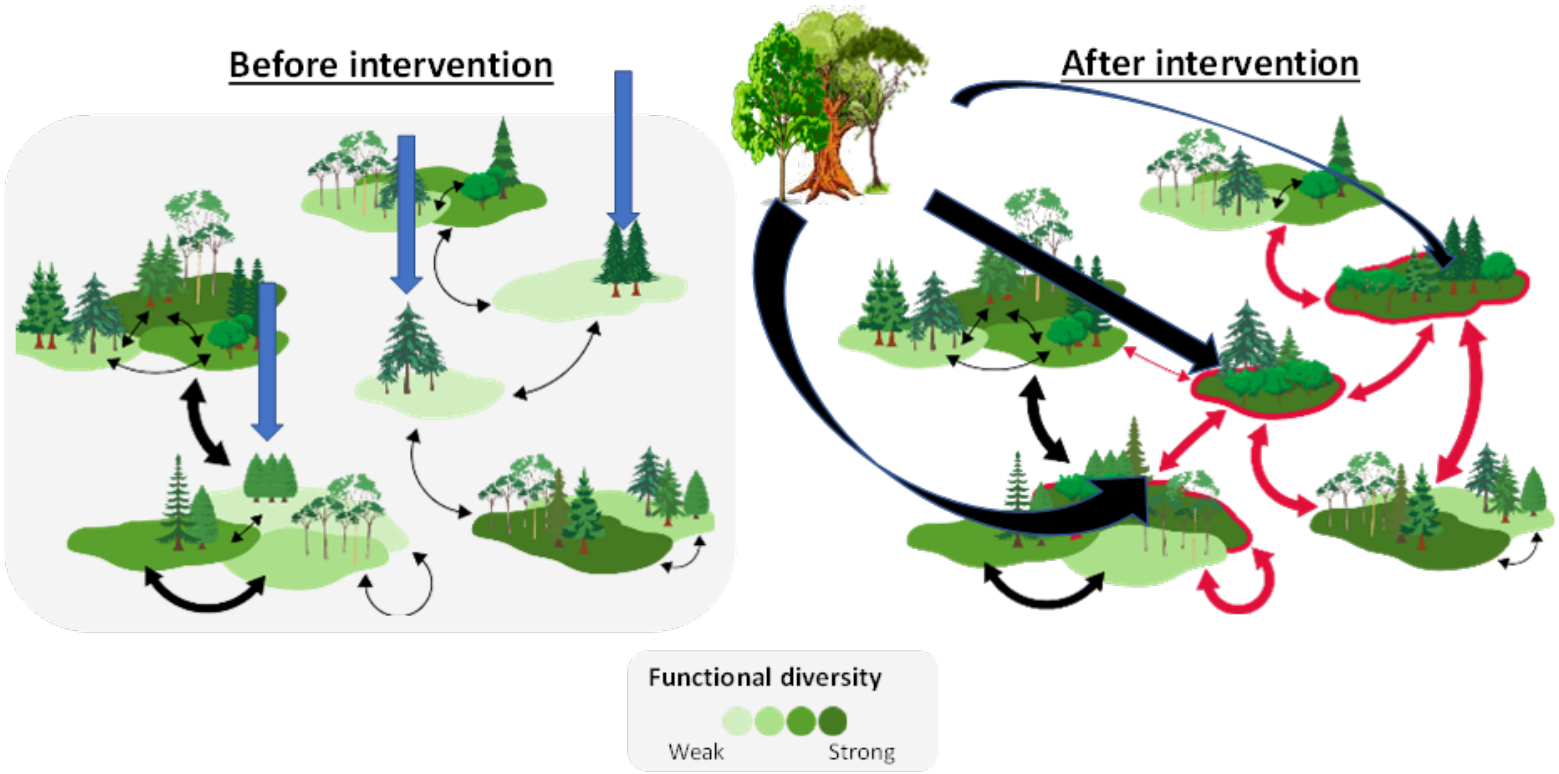

Figure 1. The functional complex network approach in practice. Left pane: Looking at the landscape level, its forest stands and their current connectivity (black arrows, thickness showing quality of connectivity), we identify forest stands which functional diversity should be increased and which improvement could create better connectivity in landscape (blue arrows). Right pane: We increase functional diversity in the selected stands, influencing both 1) resilience within stand, and 2) connectivity among stands (red arrows), therefore increasing resilience of newly connected stands down the line and increasing landscape-level resilience.

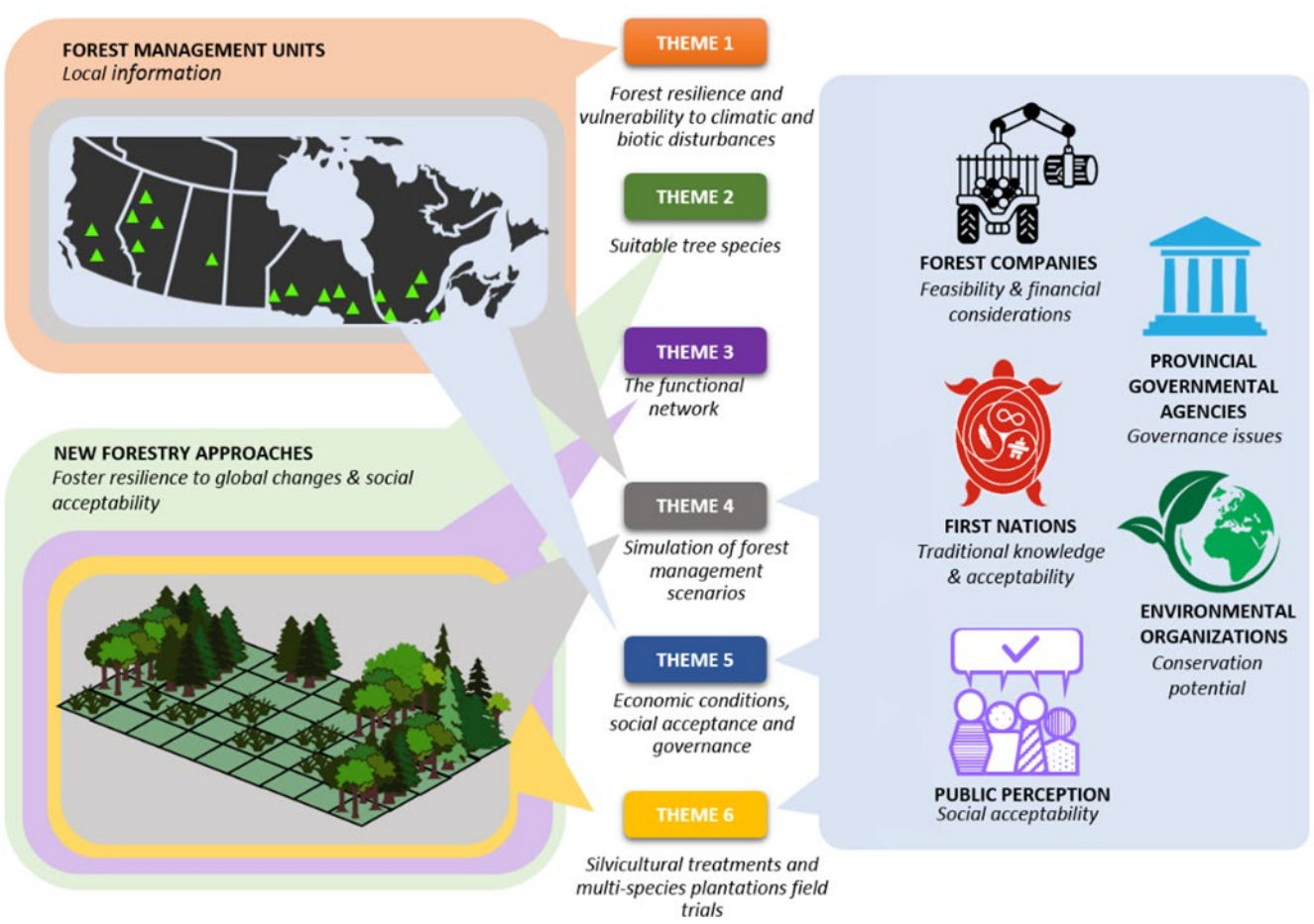

Figure 2. Project overview including the six project themes and key partners. Top left panel shows a map of the forest management areas included in the project and tested. Bottom left panel represents the Functional Complex Network approach to foster resilience to global changes. The six research themes are shown in the center. Right panel shows all included partners and stakeholders, and their direct engagement in themes 4 through 6.