DIVERSE
Adapting Forests to Global Change

Functional Complex Network

DIVERSE is a Pan-Canadian research initiative dedicated to advancing forest management through innovative approaches that emphasize functional diversity and ecological connectivity. The research encompasses six interconnected themes that aim to enhance forest resilience and sustainable forest stewardship in the face of global changes.

Theme 3 Goals & Objectives

Theme 3 aims to develop measurements of forest resilience and connectivity that will be crucial for enhancing forest resilience to novel environmental and climatic conditions across the DIVERSE Project sites. The key objectives include:

1) **Quantify Forest Resilience:** Assess resilience at stand and landscape scales using the following properties: (1) functional diversity of forest stands (where a stand is considered as a node); (2) functional redundancy and functional diversity at the stand/node level; (3) connectivity among forest stands based on tree seed dispersal capacity (where dispersal links forest stands); and (4) landscape modularity that limits the spread of disturbances;

2) **Enhance Connectivity and Fire Resilience:** Determine locations where new forest stands (nodes) are needed to improve connectivity and resilience of the forested landscape;

3) **Mapping Resilience:** Develop an interactive web application to visualize properties cited above for each DIVERSE site, guiding solutions such as tree species selection and spatial configurations.

Value Statement

The production of resilience maps for each DIVERSE site, accessible via an interactive web application, will empower partners to prioritize forest operations that enhance resilience, ensuring forests can adapt to future challenges.

Scientific Background

The Functional Complex Network (FCN) approach, introduced by Messier et al. (2019), combines network theory with functional traits to design resilient forest landscapes. By modifying forest stands (nodes) through silviculture practices, FCN may enhance functional diversity and connectivity while mitigating risks like wildfire and insect outbreaks.

Key innovations:

• Create functional networks by enriching existing stands or planting species with traits suited to future climatic conditions (e.g., drought resistance);
• Adapt forest management to balance timber yields, biodiversity, ecosystem services, and forest resilience under global change.

Methodology

1. **Delineate forest stands:** classify forest types across Canada ecozones (i.e., temperate forests, boreal forests) for timber yields and wildlife conservation;

2. **Successional Pathways:** Propose species assemblages to improve resilience against threats like drought, wildfire, and insect outbreaks;

3. **Spatial Configurations:** Develop functional forest networks by arranging forest stands to maximize connectivity or modularity as needed;

4. **Simulation Models:** Test alternative compositions and spatial configurations using the LANDIS-II model to validate the FCN approach (see figure 1 below to understand the key features of FCN)
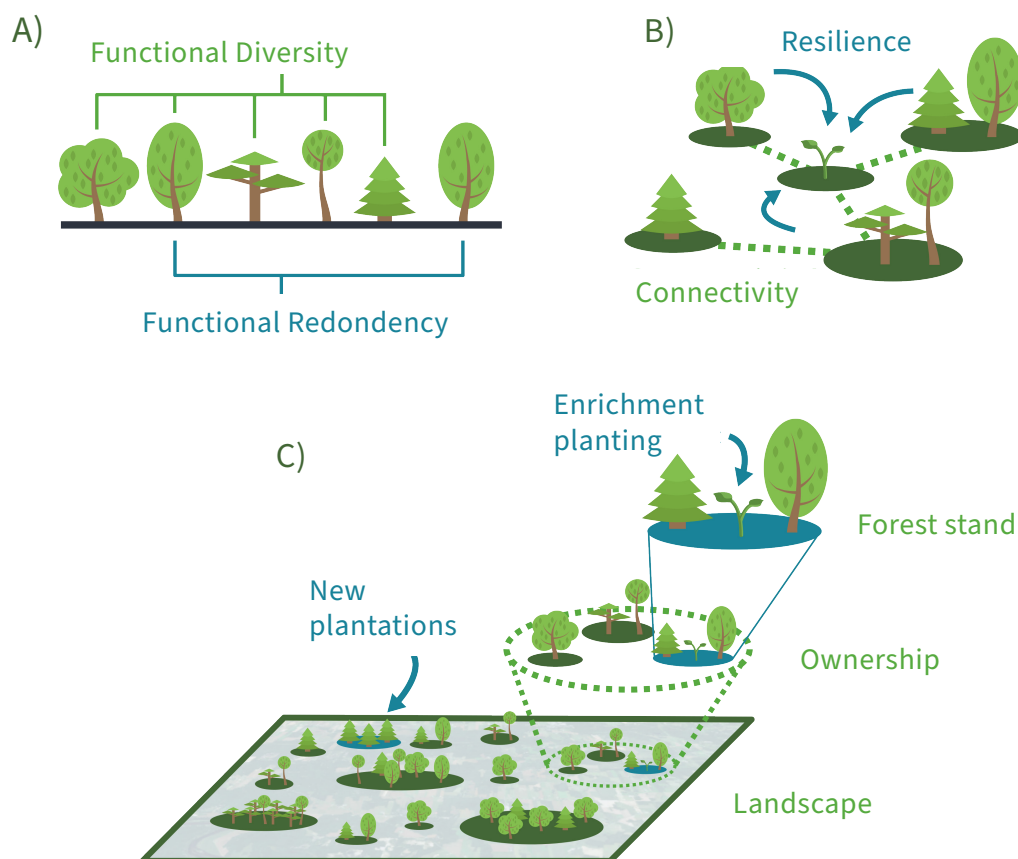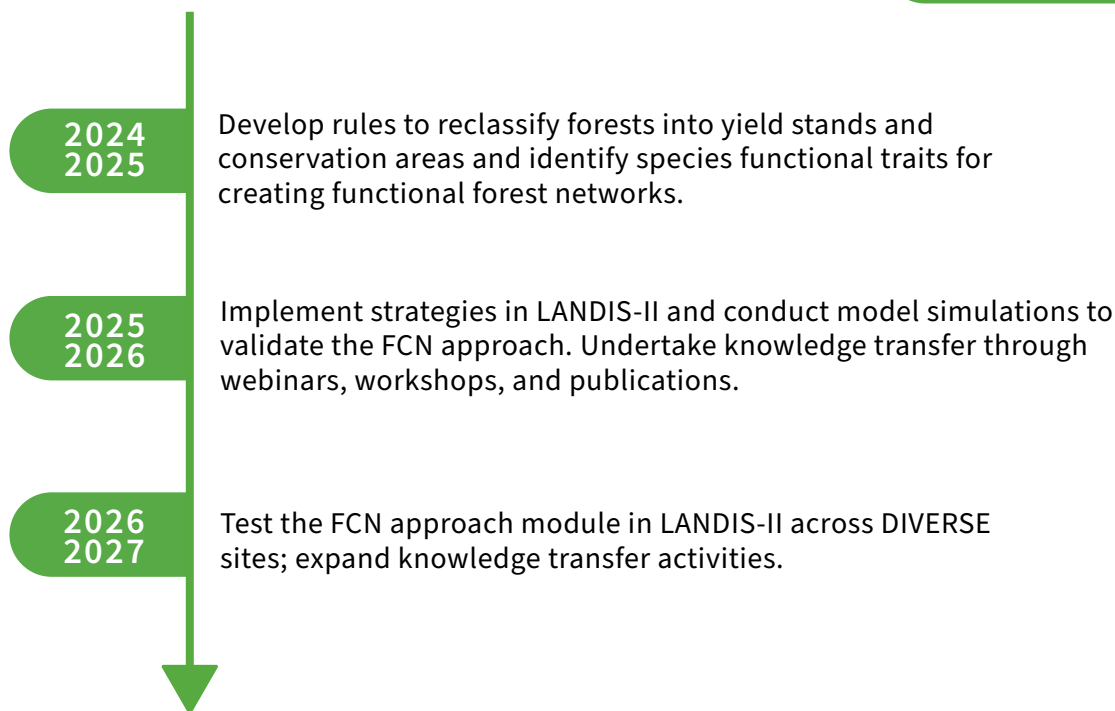

Figure 1. Depiction of the key features of the Functional Complex Network Approach: (a) species function traits [measured using functional diversity and redundancy], (b) network of forest stands [measured using connectivity, centrality, and modularity], and (c) silviculture strategies promoting overall forest resilience (adapted from Messier et al. 2019).

Timeline

2024 2025 Develop rules to reclassify forests into yield stands and conservation areas and identify species functional traits for creating functional forest networks.

2025 2026 Implement strategies in LANDIS-II and conduct model simulations to validate the FCN approach. Undertake knowledge transfer through webinars, workshops, and publications.

2026 2027 Test the FCN approach module in LANDIS-II across DIVERSE sites; expand knowledge transfer activities.

Inter-Theme Links

- **Themes 1 and 2:** Provide data and knowledge related to species traits and functional diversity to inform forest stand composition and network design;

- **Theme 4:** Collaborate on implementing the FCN approach in LANDIS-II to simulate resilience under different scenarios;

- **Theme 5:** Incorporate socio-economic constraints into the FCN approach;

- **Theme 6:** Implement and test FCN-designed strategies in the field.

Project Personnel

Theme 3 is led by a researcher from the University of Toronto, with support from Université du Québec en Outaouais, University of Alberta, Ontario Forest Research Institute, NCASI, Eurac Research, and Centre Tecnològic Forestal de Catalunya.

Highly-Qualified Personnel (HQP): 1 PhD and 1 Post-Doctoral Fellow.

Projected Deliverables

- **Resilience Strategies:** Develop alternative silviculture strategies tailored to site-specific conditions, focusing on species diversity, spatial configurations, and disturbance resilience.

- **Interactive Maps:** Create a web application (e.g., Shiny package) to visualize resilience properties and prioritize management actions.

- **Knowledge Transfer:** Disseminate findings through scientific papers, webinars, workshops, and partner engagement.