DIVERSE: Implementing the Functional Complex Network Approach Alongside Climate-Smart Forestry in Canada

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ABSTRACT

Canada's forest sector must maintain wood supply, carbon storage, biodiversity, and social values as climate change and other global stressors increase the risk of disturbance and threaten forest resilience. Climate-Smart Forestry (CSF) offers an important framework for integrating adaptation, mitigation, and socio-economic objectives, but practitioners often lack spatial decision support tools that connect stand-level actions to landscape-scale resilience under uncertain future conditions. We introduce DIVERSE, a pan-Canadian research partnership working across 22 managed-forest landscapes (>20 Mha) to implement and test the Functional Complex Network (FCN) approach as a spatially explicit, resilience-oriented planning method aligned with CSF. FCN represents landscapes as networks of stands and combines functional trait diversity and redundancy with network properties, including connectivity, centrality, and modularity, to identify where diversification, conservation, or spatial reconfiguration can enhance resilience while limiting ecosystem-wide risk. We summarize DIVERSE's six integrated research themes and operational products: (1) vulnerability and trait baselines; (2) climate-adaptation guidance for species and seed sources; (3) FCN-based resilience assessment and prioritization; (4) climate and management scenario testing through landscape simulation; (5) socio-economic feasibility analyses; and (6) operational field experiments. DIVERSE will evaluate where and when FCN can improve the robustness of forest management in Canada and support the long-term sustainability of future Canadian forests.

Key words: assisted migration; business-as-usual; Climate-Smart Forestry; climate change; ecosystem services; Functional Complex Network; forest resilience; global change; landscape planning; landscape simulation; network analysis; sustainable forest management

RÉSUMÉ

Le secteur forestier canadien doit maintenir l'approvisionnement en bois, le stockage du carbone, la biodiversité et les valeurs sociales alors que les changements climatiques et d'autres facteurs de stress mondiaux augmentent le risque de perturbations et menacent la résilience des forêts. La foresterie climato-intelligente (CSF) offre un cadre important pour intégrer les objectifs d'adaptation, d'atténuation et socio-économiques, mais les praticiens manquent souvent d'outils spatiaux d'aide à la décision permettant de relier les interventions à l'échelle du peuplement à la résilience à l'échelle du paysage dans des conditions futures incertaines. Nous présentons DIVERSE, un partenariat de recherche pancanadien travaillant dans 22 paysages forestiers aménagés (>20 Mha) afin de mettre en œuvre et de tester l'approche des réseaux fonctionnels complexes (FCN) comme méthode de planification spatialement explicite, axée sur la résilience et alignée avec la CSF. La FCN représente les paysages comme des réseaux de peuplements et combine la diversité et la redondance des traits fonctionnels avec des propriétés de réseau, notamment la connectivité, la centralité et la modularité, afin d'identifier où la diversification, la conservation ou la reconfiguration spatiale peuvent renforcer la résilience tout en limitant les risques à l'échelle de l'écosystème. Nous résumons les six thèmes de recherche intégrés et les produits opérationnels de DIVERSE : (1) vulnérabilité et données de référence sur les traits; (2) orientations d'adaptation climatique pour les espèces et les sources de semences; (3) évaluation et priorisation de la résilience fondées sur la FCN; (4) mise à l'essai de scénarios climatiques et de gestion au moyen de simulations paysagères; (5) analyses de faisabilité socio-économique; et (6) expériences opérationnelles sur le terrain. DIVERSE évaluera où et quand la FCN peut améliorer la robustesse de l'aménagement forestier au Canada et soutenir la durabilité à long terme des forêts canadiennes futures

Mots clés: aménagement forestier durable; analyse de réseau; changement global; changements climatiques; foresterie intelligente face au climat; maintien du statu quo; migration assistée; planification du paysage; réseau complexe fonctionnel; résilience des forêts; services écosystémiques; simulation paysagère

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Introduction

Since the early 1990s, Canada has pursued a Sustainable Forest Management (SFM) approach that sought to embed, through legislation and certification systems, the principle that forest management should sustain not only timber yield but also biodiversity, wildlife habitat, and other ecosystem services, including water quality, carbon sequestration, Indigenous rights, and values, knowledge systems, and stewardship priorities (CCFM 1992; NRCan 1995). Over time, SFM has increasingly incorporated ecosystem-based management (EBM) principles, particularly through coarse-filter approaches that use natural disturbance regimes, natural forest patterns, and the natural range of variation (NRV) as ecological reference points. These concepts have been reflected in policy and planning requirements in some jurisdictions and adopted by several forest companies as a management paradigm. In practice, provincial agencies have generally implemented this approach through forest management planning and policy, landscape-level indicators, retention and old-forest targets, harvest-pattern guidelines, and coarse-filter biodiversity strategies, often complemented by fine-filter measures for species or habitats of particular concern. In the Canadian context, these considerations are not merely cultural add-ons; they are part of the governance and decision-making framework within which forest management objectives are defined and applied. More recently, however, the operating environment has changed rapidly, prompting questions about whether SFM alone remains sufficient to ensure either economic or environmental sustainability. Climate change and other global stressors are altering temperature and moisture regimes, shifting wildfire dynamics, increasing both native and non-native pest pressures, modifying insect outbreak regimes, and raising the likelihood of novel disturbance sequences and regeneration failures, all of which may threaten the carbon sink capital of Canada's forests (Allen *et al.* 2010; Kurz *et al.* 2013; Seidl *et al.* 2017; IPCC 2021; Reich *et al.* 2022; Byrne *et al.* 2024). Forestry-related effects must also be considered when evaluating overall forest dynamics (e.g., Jogist *et al.* 2026; MacDonald *et al.* 2026). At the same time, managed forests are expected to deliver an increasingly broad range of values, including reliable wood supply, biodiversity and habitat conservation, sustaining watershed and soil functions, climate change mitigation through carbon storage and substitution, maintenance of Indigenous values, and respect for social values and rights (NCASI 2026), while remaining economically viable. The result is a decision challenge: silvicultural decisions made today have long-lasting consequences, including for the infrastructure that will need to be maintained, yet future conditions are increasingly uncertain and poorly represented by historical variability. Approaches that optimize for a single expected future are therefore riskier; instead, forest managers must increasingly shift toward strategies that build resilience and preserve options across a wide range of plausible futures (Millar *et al.* 2007; Puettmann *et al.* 2009; Mina *et al.* 2022; NCASI 2026).

Climate-Smart Forestry (CSF) has emerged as a growing branch of SFM that seeks to manage forests in response to climate change (Bowditch *et al.* 2020). As Bowditch *et al.* (2020) argue, "*specific CSF strategies are viewed as a way forward for developing suitable management responses and enhancing the provision of ecosystem services.*" Ecosystem services include the goods and benefits people derive from nature, such as food, fuel and fibre; regulating functions such as climate stabilization, water quality, and flood control; and non-material benefits such as aesthetic value and recreation (Dee *et al.* 2025). Yet as global change intensifies, uncertainty is growing about whether current CSF strategies will be sufficient to sustain these services in the long term.

Here we provide an overview of the DIVERSE Project, a pan-Canadian research partnership that translates recent advances in resilience science into operational decision support for forest management. The project builds on theoretical foundations from several disciplines: a) functional ecology and community ecology, which have highlighted the importance of succession, niche complementarity, and the plant economics spectrum; (b) landscape ecology, which has emphasized the importance of connectivity between stands and broader spatial scales; (c) disturbance ecology, which has advanced concepts such as disturbance regimes, resistance, resilience, and patch dynamics; and (d) silviculture, which has underscored the role of human intervention in shaping forest development pathways over time. DIVERSE integrates these foundations into a single framework, the Functional Complex Network (FCN) recently developed by Messier *et al.* (2019). In this paper, SFM is treated as the broader management foundation, CSF as a climate-focused framing within that foundation, and FCN as a spatially explicit, resilience-oriented planning and decision support approach that can be compared with, and in some cases used alongside, business-as-usual (BAU) and CSF-oriented strategies. Its central premise is that forest resilience depends not only on stand composition, but also on the spatial arrangement of stands and their functional connectivity within and across broader landscapes. DIVERSE therefore evaluates FCN as a spatially explicit resilience-oriented planning approach, testing its performance relative to BAU and CSF-oriented strategies. A key outcome of the project will be a set of spatial prioritization tools that can help managers identify where in the landscape diversification, protection, and connectivity-oriented interventions are most likely to reduce vulnerability and strengthen forest recovery and adaptive capacity through time.

Sustainable Forest Management (SFM) and Climate-Smart Forestry (CSF) as a Foundation

SFM has provided the policy and operational foundation for forest management in Canada. It is commonly framed as an adaptive and evolving approach intended to maintain and, where possible, enhance the environmental, social, and economic values of forests over the long-term (CCFM 2008; United Nations General Assembly 2008; Williamson and Nelson 2017). At its core, SFM adopts a holistic, ecologically informed approach that seeks to balance economic, environmental, and social values across multiple spatial and temporal scales (Gauthier *et al.* 2023). In practice, it is implemented through a multi-layered system of regulations, planning requirements, third-party certification, and voluntary best management practices (Gilani and Innes 2020; NCASI 2025). Canada's SFM approach has also been shaped by internationally agreed criteria and indicators (e.g., the Montréal Process 2015) and nationally by the Canadian Council of Forest Ministers' criteria and indicators framework for monitoring progress toward SFM objectives (CCFM 1995). This institutional context matters because it already embeds many of the elements now emphasized in climate-focused frameworks, including biodiversity conservation, climate-related risk reduction, and collaboration with Indigenous governments, organizations, and rights holders, within routine planning and accountability structures (NCASI 2026).

Under global change, however, the sources of uncertainty are increasingly daunting. Future disturbance regimes, climate trajectories, pest dynamics, markets, and social priorities may shift in ways that are difficult to forecast or even characterize with confidence. In this context, strategic forest planning is less about identifying a single optimal strategy based on a limited set of commercial tree species and more about developing landscapes that remain robust across many plausible futures while retaining their capacity to provide forest ecosystem services (Westphal *et al.* 2023). This framing aligns with the reality that forest managers must operate within legislative and regulatory frameworks (NCASI 2025), amid growing complexity and uncertainty, while also considering regional impacts and treatment effectiveness (Dee *et al.* 2025).

CSF can be described as an evolution or extension of SFM that explicitly integrates three interdependent objectives: (i) facilitating forest adaptation to climate change and related stressors; (ii) contributing to climate change mitigation through carbon sequestration, storage, and substitution; and (iii) sustaining social values, including equity, First Nations and other Indigenous rights and values, other cultural values, and broader social priorities (Bowditch *et al.* 2020; NCASI 2026). CSF is not a silvicultural system in itself; rather, it is a decision framework that can be implemented through a range of stand- and landscape-level actions. These may include climate-informed species and provenance selection, diversification of stand composition and structure, climate risk mitigation where appropriate (e.g., fuel management), and spatial planning approaches that maintain multiple ecosystem services.

An important contribution of CSF is its explicit recognition that adaptation and mitigation interact and can generate both synergies and trade-offs, not only for forest ecosystems but also for forest-dependent communities, Indigenous Peoples, industry, land managers, and other stakeholders (Reich *et al.* 2025). Actions that reduce near-term disturbance (anthropogenic and natural) risk can enhance forest persistence, while measures that improve regeneration under warmer, drier, or more variable climates can support recovery and shape post-disturbance reorganization. Taken together, these measures may help protect long-duration carbon pools, maintain fibre supply, and reduce the likelihood of abrupt carbon and biodiversity losses from high-severity disturbance. Conversely, strategies designed to maximize near-term carbon accumulation may, in some contexts, increase exposure to severe wildfire, insect, and disease outbreaks if they promote homogeneous stand structures, shift to older age classes, or concentrate value in high-risk areas. Because carbon dynamics, biodiversity outcomes, and wood supply operate on multi-decadal time frames, CSF decision-making should evaluate alternatives over longer time horizons and under a range of uncertainty scenarios (Nabuurs *et al.* 2017; NCASI 2026).

In the Canadian context, SFM, often operationalized through EBM principles, and CSF are anchored in explicit ecosystem service priorities and require managing trade-offs among them (Maulin *et al.* 2016). Industry, governments, Indigenous rights holders, and other stakeholder groups are increasingly expected to deliver and balance biodiversity and habitat protection, wood supply, carbon storage and climate mitigation benefits, and water regulation, while also advancing Indigenous rights, values, knowledge systems, and broader social priorities (NCASI 2026). This reinforces the need for climate-oriented decision-making to be multi-objective and for practitioners to have tools that make trade-offs transparent across spatial and temporal scales. As a result, CSF is increasingly reflected in operational discussions and pilot initiatives (Antwi *et al.* 2024a,b), including efforts to expand the use of mixed species and structural diversity in silviculture, incorporating climate considerations into seed transfer and deployment, and developing adaptation frameworks that link vulnerability assessments to actionable intervention options (Aitken *et al.* 2008; Pedlar *et al.* 2012; Wotherspoon *et al.* 2025). However, because DIVERSE is a pan-Canadian initiative, it is important to recognize that the uptake, terminology, and policy relevance of SFM, CSF, and related climate-adaptation approaches vary among provinces and tenure systems. Nonetheless, although SFM and CSF are widely recognized as multi-scale endeavours, many current climate adaptation actions remain generally experimental and are still implemented primarily at the stand scale (Antwi *et al.* 2024a,b). In this paper, CSF is therefore used as a cross-jurisdictional comparative framework rather than as a term uniformly embedded in provincial legislation or practice.

Functional Diversity to Enhance Productivity and Disturbance Resilience under Climate Change

Functional trait diversity, defined here as the range, values, and distribution of species traits within an ecosystem, is a key driver of ecosystem function and often exerts a stronger influence on biomass production and stability than species richness alone. Under climate change, greater functional diversity can enhance productivity through niche complementarity, whereby species with different traits use resources, tolerate stress, or respond to environmental variation in different ways. Examples include differences in rooting depth, shade tolerance, drought tolerance, nutrient-use strategy, or leaf phenology, which can allow forests to capture resources more effectively or maintain function under variable conditions (Tilman *et al.* 1997; Hooper *et al.* 2005). In a forest management context, such complementarity need not require intimate species mixtures within every stand but may also be expressed through mixtures among stands or through landscape-level diversification.

Functional diversity also buffers ecosystems against environmental variability by strengthening resistance, the capacity to withstand natural disturbance, and resilience, the capacity to recover afterward. For example, a resistant forest may contain fire-adapted, thick-barked trees that are more likely to survive low-intensity surface fires with little mortality (Holling 1973), whereas a resilient forest may experience substantial storm damage but recover rapidly through seed banks or vegetative sprouting (Walker *et al.* 2004). This buffering capacity is central to the climate insurance hypothesis, which proposes that a portfolio of species with overlapping functional roles but differing environmental tolerances will help sustain ecosystem processes even when a particular taxon is lost to drought, wildfire, or pest outbreaks (Yachi and Loreau 1999; Oliver *et al.* 2015). Accordingly, forest stands with high functional trait dispersion (FDis), a measure of how far species deviate from the community-average trait values, may be better positioned to sustain ecosystem functioning following disturbance than functionally simplified monocultures (Laliberté and Legendre 2010; Isbell *et al.* 2015). Prioritizing functional diversity is therefore an important strategy for maintaining ecosystem multifunctionality in an uncertain climate future (Diaz *et al.* 2007; Mori *et al.* 2013).

Adaptive Forest Management at Multiple Scales

Forest landscapes are complex social and ecological systems shaped by climate, soils, natural disturbance regimes, species interactions, and human land use and decisions that interact across nested spatial and temporal scales (Allen and Starr 1982; Waring and Running 1998; Filotas *et al.* 2014; Fischer 2018). Under global change, stand-level management alone is increasingly ineffective because resilience depends not only on the characteristics present within individual stands, such as composition, functional traits, and ecological legacies (Johnstone *et al.* 2016), but also on how these elements are arranged across the broader forest landscape, including stand configuration, connectivity, and degree of compartmentalization (García-Abril *et al.* 2013). A multi-scale perspective is therefore essential for translating SFM, EBM, and CSF goals into robust action under increasing situational uncertainty (Perera *et al.* 2004; Filotas *et al.* 2014; Messier *et al.* 2019). Although several provinces explicitly incorporate multiple scales into forest management policy and planning (e.g., British Columbia's Forest Landscape Planning tables; Ontario's Crown Forest Sustainability Act 1994; Alberta's Forest Planning Standard, ARSD 2006), landscape-scale planning has generally remained limited, and insufficient attention has been paid to the ways in which landscape patterns and processes can help mitigate threats associated with global change.

At broader spatial scales, landscape connectivity can strengthen resilience by facilitating the movement of organisms, genes, and functional traits across space (Filotas *et al.* 2023). This idea is not new: Merriam (1984) emphasized the importance of landscape connectivity, building on earlier foundations in island biogeography (MacArthur and Wilson 1967) and metapopulation theory (Levins 1969). Well-connected networks of stands can support post-disturbance recolonization and help maintain ecosystem functioning when local populations are lost or stressed (Craven *et al.* 2016). Connectivity can also enhance biodiversity by sustaining habitat continuity for species that depend on patch networks within fragmented regions (Pither *et al.* 2023; Daly *et al.* 2025). In addition, landscape integration across watersheds links forest structure to water quantity and quality (Webster *et al.* 2022). In these ways, connectivity enables local adaptation and management actions to scale up, anchoring forest responses in processes that operate well beyond individual stands.

At the same time, landscape features that can facilitate recovery, including spatial diversity in forest age classes, species composition, and habitat configuration, can also amplify disturbance. Reviews across multiple boreal and temperate taxa show that host abundance and configuration strongly influence pest outbreak severity and spread (Raffa *et al.* 2008; Kneeshaw *et al.* 2021; Sturtevant *et al.* 2023). Similar dynamics apply to wildfire, where decades of fire suppression have produced extensive fire-deficit landscapes dominated by older, more flammable fuels (Alexander *et al.* 1995), increasing the likelihood of large, high-severity events and atypical wildfire behaviour (Parisien *et al.* 2020). Cross-scale analyses further show that disturbance behaviour, carbon outcomes, and future risk depend heavily on landscape-level fuel continuity rather than stand conditions alone (Loehman *et al.* 2014). Climate change often intensifies these patterns by increasing the frequency of extreme weather (elevated temperatures, heat domes, droughts, precipitation infrequency), lengthening disturbance-prone seasons, and strengthening interactions among climate, fuels, and biotic agents (Seidl *et al.* 2017). The risk of invasive pests is similarly shaped by both climatic conditions, including range expansion through warmer winters, and landscape connectivity (Srivastava *et al.* 2021).

Together, these dynamics highlight a central challenge in meeting SFM, EBM, and CSF objectives: the costs and benefits of connectivity, diversity, and spatial configuration become fully apparent only when viewed across broader spatial scales.

Connectivity can accelerate regeneration and sustain biodiversity, but it can also increase exposure to fire, disease and insect outbreaks when it creates continuous corridors of susceptible fuels and hosts. Conversely, modular or semi-independent landscape clusters can slow the spread of disturbance, yet they can also affect ecosystem function and hinder recovery if they become too isolated. Navigating these trade-offs requires a unifying framework that integrates functional diversity, spatial configuration, and multi-scale disturbance processes into operational decision support, explicitly accounting for uncertainties.

These insights motivated the development of the Functional Complex Network (FCN) approach and, by extension, the initiation of the DIVERSE Project. The project goal is to translate resilience principles into operationally meaningful questions and approaches about where diversification, protection, and connectivity-oriented interventions can have the greatest long-term positive/beneficial effect in the continued provision of ecosystem services from the forest under climate change-induced high uncertainty, while remaining aligned with SFM, EBM, and CSF objectives and responsive to local decision contexts.

The Functional Complex Network (FCN) Approach

The use of network models to represent ecological connectivity has a long history in forest ecology, conservation, and management. As early as 1966, Kanzaki (1966) applied graph theory to the efficiency of forest road networks. Later, Bunn *et al.* (2000) showed that simulated patch removal could identify elements most critical to network integrity, while Urban and Keitt (2001) formalized a graph-theoretic perspective in ecology by linking connectivity to metapopulation persistence. Pascual-Hortal and Saura (2006) subsequently introduced widely used connectivity indices, and Fall *et al.* (2007) helped bring these ideas into forest planning and decision support.

The FCN concept builds on these earlier applications of graph theory by explicitly incorporating functional traits into the representation of forest landscapes. It also differs from many previous approaches by treating trees, rather than wildlife habitat, as the focal organisms. In this view, connectivity emerges from the spatial arrangement of stands and from the dispersal, growth, and disturbance resistance functional traits of the trees they contain, rather than from the suitability of the stands as sites for wildlife occupancy.

FCN represents forest landscapes as networks in which nodes correspond to forest stands or patches and links represent the potential movement of regeneration and functional traits across space (Messier *et al.* 2019). This perspective reframes resilience from a purely stand-level property to an emergent characteristic of landscape structure, arising from how functionally diverse stands are distributed, connected, and buffered against cascading effects associated with changing disturbance regimes and disturbance interactions (Sturtevant and Fortin 2021).

This FCN framework strives to increase resilience through a set of complementary properties operating at different scales. At the stand (node) scale, FCN emphasizes (1) functional diversity: range of ecological strategies and species traits present, and (2) functional redundancy: extent to which multiple species can provide similar functions (Fig. 1). Together, diversity and redundancy provide a level of insurance under change and uncertainty by increasing the likelihood that some species or functional types will maintain key processes when conditions shift, or stressors intensify (Yachi and Loreau 1999; Mori *et al.* 2013; Schindler *et al.* 2015). Functional diversity may also directly enhance productivity, carbon sequestration and storage, and ecosystem stability (Chen *et al.* 2023; Ding *et al.* 2024; Zheng *et al.* 2024). At the landscape scale, FCN emphasizes (3) functional connectivity: the capacity for functionally diverse regeneration to recolonize disturbed areas, which is approximated by using dispersal potential with proximity and stand composition (Craven *et al.* 2016; Messier *et al.* 2019; Aquilué *et al.* 2021). At the network level, FCN further evaluates (4) centrality by identifying stands that disproportionately act as regeneration sources or connectors; and (5) modularity, or functional zoning, reflected in semi-independent clusters of stands within the landscape. More specifically, modularity can reduce system-wide vulnerability by limiting the pathways through which disturbances propagate across the system (Newman and Girvan 2004; Gilarranz *et al.* 2017).

Building on these principles, FCN has evolved from a theoretical construct into a management-relevant framework. Aquilué *et al.* (2021) proposed a practical approach that uses FCN metrics to prioritize interventions likely to improve adaptive capacity without requiring managers to redesign existing planning systems. Mina *et al.* (2022) further showed how FCN properties can be used to evaluate trade-offs and design forest landscapes that perform well across multiple objectives under uncertainty. DIVERSE aims to move these advances from concept to operational applications by testing FCN in managed landscapes.

What FCN adds in practice

For managers, FCN is a spatial decision-support framework and associated tools for informing targeted silvicultural interventions. Rather than focusing solely on stand-level conditions, it links local management actions to landscape-scale processes that shape vulnerability, recovery, and the propagation of disturbance. In this way, FCN directly addresses implementation challenges highlighted in recent CSF syntheses, including uncertainty about future climate and disturbance regimes, shifting values and priorities, and operational knowledge gaps about which actions to take and where to apply them (Antwi *et al.* 2024a,b; NCASI 2026).

Operationally, FCN helps address three recurring planning decisions. First, it helps identify landscapes or stand types that may be especially vulnerable under novel conditions because they lack sufficient diversity and redundancy in tree functional traits. Second, it highlights both areas of limited connectivity among stands and the converse problem: stands that are disproportionately influential in regeneration pathways because of their high centrality. A network perspective can therefore identify where protection or targeted diversification may yield outsized landscape-level benefits. Third, FCN provides a way to evaluate whether greater modularity (semi-independent clusters of forest stands and patches) could reduce system-wide disturbance propagation while maintaining the connectivity needed to support recovery over time.

The approach is designed to be implemented using data that are often already available within the forest sector, including stand inventories and land vegetation cover maps, functional trait information for locally relevant species, and reasonable assumptions about dispersal capacity. DIVERSE is explicitly testing how well these inputs can be standardized across regions and integrated into routine planning, scenario analyses, and goal-oriented forest monitoring.

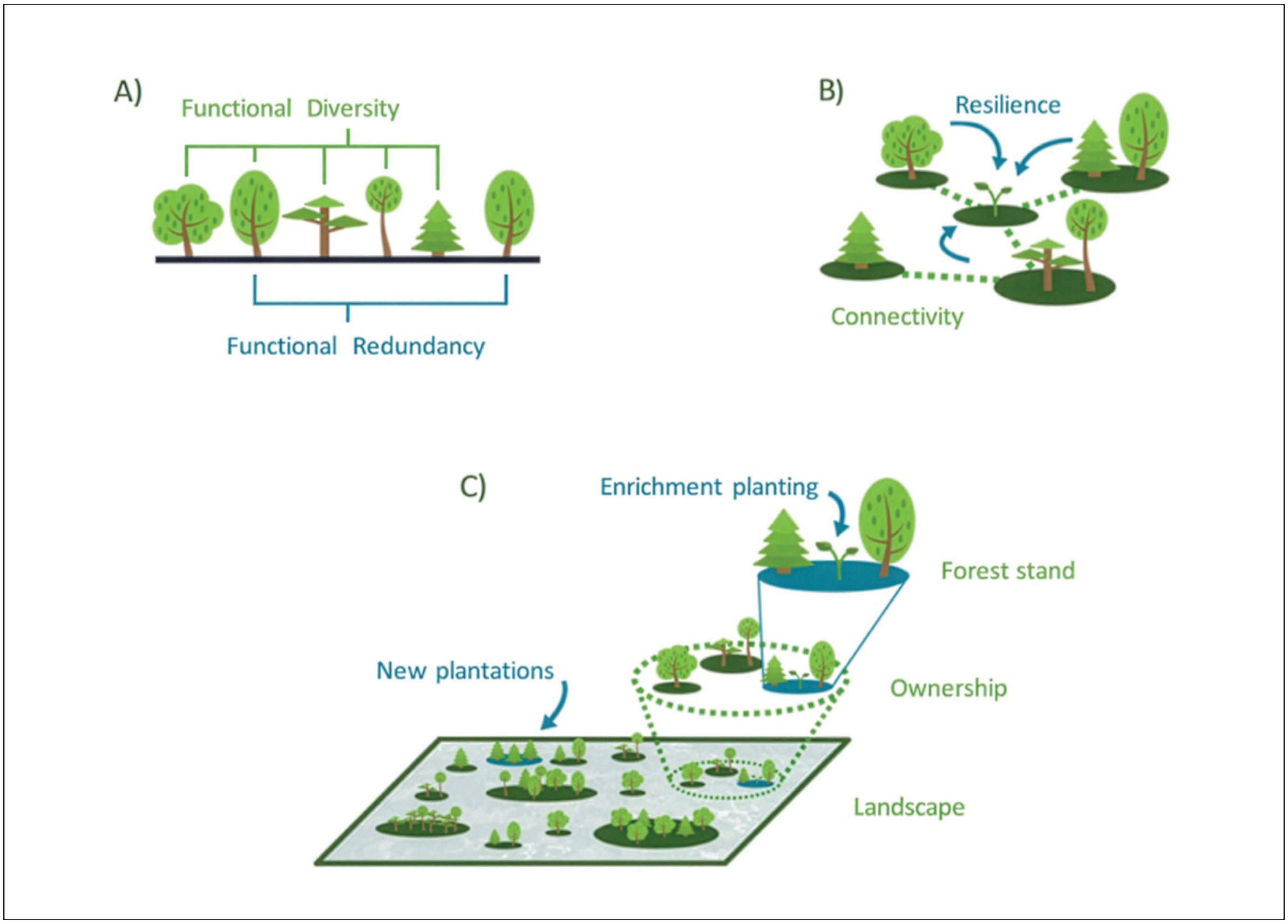

Fig. 1. Depiction of the key features of the Functional Complex Network Approach: (a) species function traits [measured using functional diversity and redundancy]; (b) network of forest stands [measured using connectivity, centrality, and modularity]; and (c) silviculture strategies promoting overall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

The DIVERSE Project

DIVERSE is a pan-Canadian research initiative focused on developing strategies and tools for strengthening forest resilience to climate change and other global stressors. Its overarching goal is to co-develop and test decision-support tools that help managers make robust, landscape-explicit choices that can enhance forest resilience under global change while supporting sustainable forest stewardship. Although improved social acceptance could emerge if these approaches are implemented and demonstrate clear benefits, fostering such acceptance is not a direct objective of DIVERSE, which will require continued collaboration, relationship building, and broader engagement processes that extend beyond the project itself.

The program is being implemented as a co-produced partnership among universities, forest sector partners, government agencies, Indigenous organizations, and other land-, rights-, and stakeholder groups. This includes collaborating with Indigenous organizations and rights holders on scenario design, prioritization, implementation pathways, and the interpretation of trade-offs, recognizing that engagement alone is not sufficient. DIVERSE brings together more than 50 researchers (including 13 co-applicants and more than 40 collaborators) across seven Canadian universities and supports the training of graduate students and post-doctoral researchers, with additional support from research professionals. Science and steering committees provide structured forums for scenario design, data sharing, research, tool review, and knowledge exchange. The current research footprint includes 22 managed-forest study sites across six provinces, representing more than 20 million hectares spanning public, private, and Indigenous forests (Fig. 2). These sites span major managed forest types across Canada and were selected to support both region-specific learning and cross-regional synthesis, and to develop a pan-Canadian view of the applicability of the FCN approach across distinct provincial policy and tenure contexts. The program is supported by partner contributions, the Natural Sciences and Engineering Research Council of Canada (NSERC) and Mitacs, with a total budget of approximately $7.5 million over the planned project duration (2023-2028).

DIVERSE is structured around six interconnected themes designed to move from diagnosis (what susceptibilities exist), to options (what species and spatial configurations can promote resilience and adaptive capacity), to testing (how those options perform under future climate and management scenarios), and ultimately to implementation (what treatments are feasible, acceptable, and operational) (Table 1).

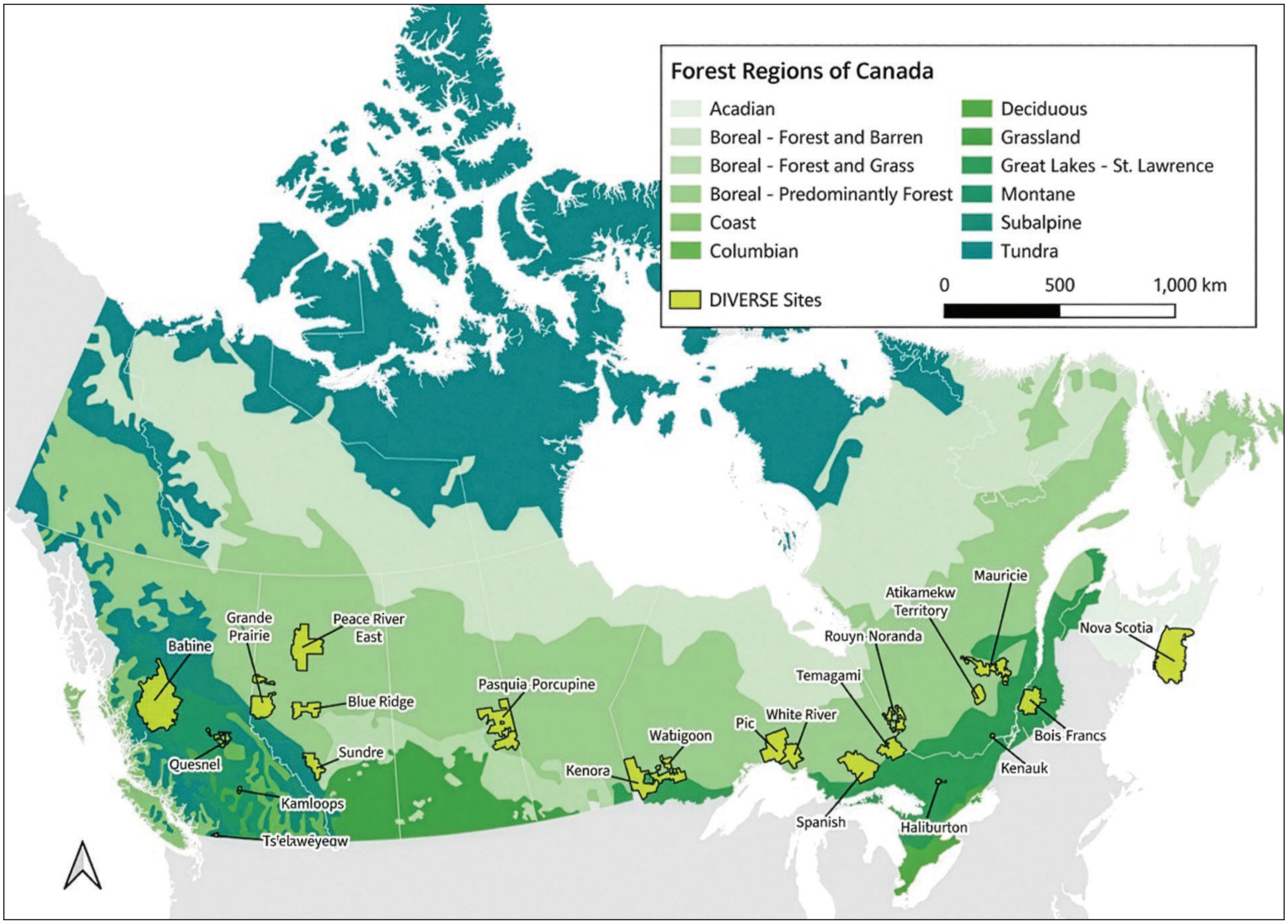

Fig. 2. Locations of the 22 DIVERSE sites across Canada.

> **Box 1. Operational Definitions used in DIVERSE**
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> For clarity, DIVERSE applies the following working definitions when comparing management strategies across landscapes:
>
> - Business as Usual (BAU): Current or historic landscape-specific forest management practices used as a baseline.
> - Climate-Smart Forestry (CSF): An integrated approach to Sustainable Forest Management (SFM) that seeks to enhance the capacity of forests to adapt to and mitigate climate change while sustaining social, cultural, and economic values derived from forest ecosystem services (Bowditch *et al*. 2020; NCASI 2026).
> - Functional Complex Network (FCN): A spatially explicit, multi-scale resilience-oriented planning and decision-support approach that incorporates tree species functional traits, diverse species composition, connectivity among stands, and landscape complexity, while accounting for long-term social-ecological uncertainty, to improve forest response to disturbances and global stressors; in DIVERSE, FCN is evaluated alongside BAU and CSF-oriented strategies (Messier *et al*. 2019).

Overview of DIVERSE Project Design

Across its themes, DIVERSE is building a decision workflow that allows FCN-informed options to be assessed alongside BAU and CSF-oriented forest management strategies under uncertainty. The workflow is intended to be iterative (diagnose – prioritize – design interventions – implement strategies – monitor and adjust) and compatible with existing forest management planning cycles, whilst providing a clear, landscape-explicit rationale for where to intervene and why.

In practical terms, DIVERSE outputs are intended to help address recurring operational questions: (1) Where are forest landscapes currently most vulnerable, and what ecological or management factors explain those patterns? (2) Where should diversification, assisted migration, and other adaptive measures be prioritized to broaden the portfolio of functional responses to future change? (3) Which stands or landscape elements are critical sources or connectors for recovery and should therefore be protected, strengthened, or reconfigured? (4) How do alternative management strategies (BAU, CSF, FCN) perform under different disturbance regimes and uncertain futures with respect to wood supply, carbon, biodiversity and habitat, water provision, and other values? (5) What are the socio-economic implications, governance constraints, rights-holder priorities, and implementation conditions associated with FCN, and how

Table 1. Summary of DIVERSE themes, scientific rationale, key products, and the operational decisions they are designed to support.

Theme	Scientific issue and rationale	Objectives and approach (high level)	Key products/outputs	Decisions supported/intended practitioner use
Theme 1 Forest Vulnerability	Establish trait-based and empirical baselines of vulnerability to climate-driven stress and regeneration failure across managed landscapes.	Compile or measure functional traits data linked to stress responses; develop vulnerability indicators and baseline resilience metrics.	• Harmonized vulnerability indicators • Functional trait datasets • Interactive baseline maps and monitoring-ready layers	• Where vulnerability to key stressors is highest • Where to prioritize diversification or other interventions • What indicators to track for adaptive management and re-entry
Theme 2 Identification of Suitable Tree Species Seed Sources	Identify species and seed sources better matched to emerging climates and link these options to functional diversity and redundancy goals.	Compile and harmonize long-term plot/inventory data; Integrate climate suitability information, evidence from provenance studies, and trait-based functional groupings; develop guidance for species/provenance selection to support CSF and FCN strategies.	• Climate-suitability and seed sourcing guidance • Assisted migration decision support (species/provenance) • Region-specific candidate species lists and maps	• Which species/provenances to deploy under warming and novel disturbance risk • Where and when to consider assisted migration • How to diversify planting portfolios to reduce future maladaptation
Theme 3 Functional Complex Networks	Translate resilience principles into landscape-explicit priorities using FCN metrics (diversity, redundancy, connectivity, centrality, modularity).	Build functional landscape networks using stand and trait data; compute FCN metrics; identify priority areas for diversification/protection; develop user-facing mapping and scenario exploration tools.	• FCN maps (functional diversity, redundancy, connectivity) • Centrality and modularity diagnostics • Prioritization layers for resilience investments	• Where to diversify to strengthen recovery potential and connectivity • Which stands act as key sources/connectors to protect or strengthen • Where spatial reconfiguration could reduce system-wide vulnerability
Theme 4 Scenario Testing with Landscape Simulation Models	Evaluate long-term performance and trade-offs of BAU, CSF, and FCN strategies under climate and disturbance uncertainty.	Implement landscape simulation models (e.g., LANDIS-II); co-design management scenarios with partners; quantify outcomes for carbon, timber, biodiversity indicators, and resilience metrics.	• BAU/CSF/FCN scenario simulations (LANDIS-II) • Multi-objective performance summaries across futures • Trade-off and robustness analyses over long horizons	• Which management strategies are robust across climate/disturbance futures • How strategies affect timber, carbon, biodiversity/habitat, and water provision • How to redesign plans when trade-offs are unacceptable or risks concentrate
Theme 5 Socio-economic feasibility, governance, and implementation pathways	Identify socio-economic, operational, governance and rights-holder constraints and enabling conditions for implementing CSF and FCN strategies.	Assess costs, benefits, risks, policy/tenure context, and acceptability; co-produce implementation pathways and recommendations with partners and rights holders.	• Feasibility assessments (costs, benefits, risk) • Governance/policy insights and implementation pathways • Guidance on enabling conditions and adoption barriers	• What is feasible and acceptable under local tenure, regulation, rights-holder priorities, and capacity constraints • Which partnerships and governance mechanisms support implementation • How to align FCN/CSF options with certification and planning requirements
Theme 6 Field Trials Demonstrations & Operational Learning	Build confidence and operational relevance through field-scale implementation, monitoring, and knowledge exchange.	Establish a subset of DIVERSE sites as demonstration sites; implement treatments informed by Themes 1–5; monitor regeneration and resilience indicators; deliver workshops and extension products.	• Field demonstrations and operational learning • Monitoring protocols and extension products • Practitioner training and knowledge-transfer materials	• Which treatments to test and how to operationalize them • How to scale or adapt prescriptions based on outcomes • How to integrate learning into iterative planning cycles

can barriers to uptake be addressed in operational practice? and (6) How can operational silviculture trials and long-term monitoring plots be used to test FCN-informed treatments, evaluate outcomes that match expectations, and identify indicators or decision triggers for follow-up treatments when outcomes diverge from expectations?

Six Interconnected Themes

Each theme addresses a key challenge in operationalizing resilience-based forest management under global change. Together, the themes provide the scientific foundation, analytical tools, and implementation pathways needed to apply the FCN approach in real planning contexts and to evaluate its value alongside BAU and CSF approaches.

Across themes, DIVERSE is intended as an end-to-end workflow rather than a collection of independent studies. Theme 1 establishes vulnerability and trait baselines that identify where emerging stress and recovery constraints are most likely to occur. Theme 2 translates climate exposure into actionable regeneration options by identifying climate-suitable species and seed sources and organizing them into functional groupings. These inputs support Theme 3, in which FCN metrics transform stand- and species-level information into landscape-specific priorities for intervention. Theme 4 then evaluates BAU, CSF, and FCN portfolios through long-horizon scenario testing to quantify trade-offs and robustness across plausible futures. Themes 5 and 6 ensure operational relevance by assessing feasibility and implementation conditions and validating decision support through field demonstrations and monitoring. Together, these themes create feedback loops that refine tools, indicators, and implementation guidance over time. The challenge is connecting all of these for a given location, context, and management system.

Theme 1: Forest Vulnerability

Rationale. Global change is increasing forest exposure to drought, fire, native and invasive pests and diseases, and other stressors, thereby altering disturbance regimes and increasing the likelihood of regeneration failure in many forest types. Trait-based approaches provide a mechanistic framework for interpreting how species and communities respond to changing conditions and for identifying where current compositions may be most vulnerable (Aubin *et al.* 2018).

Objectives. Theme 1 aims to: (1) assess the vulnerability of Canadian forests to global change; (2) use functional traits to characterize tree species' sensitivity to major stressors; and (3) develop indices and tools to assist the Canadian forest sector in designing robust climate change adaptation plans.

Approach. This theme will fill key knowledge gaps in tree traits through collaborative field campaigns and targeted research. Trait data will be compiled into a ready-to-use format for modelling, both to improve predictive performance and to make the information more accessible for future large-scale projects. Species-specific sensitivity indices will be developed for four major risks: (1) drought-induced mortality; (2) migration failure; (3) increased fire severity and recurrence; (4) regeneration failure; and (5) invasive pests. These indices will be based on trait information for 77 tree species in Canada. Combined with stand composition data and climate projections, they will support spatially explicit assessments of forest vulnerability to major global change stressors. These products will provide stand-level functional inputs for FCN analyses in Theme 3, support parameterization of landscape simulation models in Theme 4, and help identify candidate species for field trials in Theme 6.

Outputs. Deliverables will include curated tree trait datasets, indices of tree species sensitivity to major stressors, and spatially explicit vulnerability assessments presented in formats that support comparison across climate risks and regions. Practitioners will be able to use these products to: (a) visualize different climate-change impacts; (b) identify vulnerability hotspots; (c) prioritize areas where intervention is most needed; and (d) support the development of tailored adaptation strategies.

Theme 2: Identification of Suitable Tree Species Seed Sources

Rationale. In many regions, current tree species, provenances, species mixtures, and local seed sources may become increasingly mismatched with future climate conditions (e.g., species out of their theoretical or realized physiological tolerance limits or climatic envelopes; Dendoncker *et al.* 2026). Adaptation options, therefore, include shifting species composition and selecting seed sources better matched to emerging climates, while also managing uncertainty related to seed supply, and governance (Aitken *et al.* 2008; Pedlar *et al.* 2012; Solarik *et al.* 2018; Wotherspoon *et al.* 2025). Within an FCN framework, climate-adapted species and provenances can also contribute to functional diversity and build redundancy into climate resilience development, strengthening recovery pathways after disturbance.

Objectives. Theme 2 aims to: (1) identify climate-suitable tree species and populations for each biogeoclimatic region represented in DIVERSE landscapes; and (2) develop spatially-explicit, locally-derived functional groupings of species and provenances to support climate resilience building diversification planning.

Approach. Theme 2 integrates current species distribution data, multi-model climate projections, and empirical evidence from provenance and common-garden studies (where available) into tools for species and seed selection, as well as locally relevant, trait-based functional groupings. These outputs are designed to feed directly into FCN mapping (Theme 3), scenario testing (Theme 4), and field trials (Theme 6) by defining realistic regeneration and composition options under both CSF- and FCN-oriented strategies.

Outputs. Deliverables will include climate-suitability layers for candidate species, provenances, and seed sources; functional groupings to support diversification planning; and guidance that can be incorporated into regeneration prescriptions, planting programs, and enrichment strategies. These GIS layers are intended to enhance local practitioners' knowledge (soils, topography, competition, etc.) by providing a broader portfolio of species and provenances. Taken together, an expanded range of candidate species and provenances should increase the likelihood of establishment and long-term performance under future climates while increasing functional redundancy and reducing the risk of widespread maladaptation to future climate conditions.

Theme 3: Functional Complex Networks

Rationale. The FCN approach provides a practical framework for translating resilience concepts into landscape-specific action priorities. By quantifying functional diversity, redundancy, connectivity, centrality, and modularity, FCN can help identify where interventions are most likely to strengthen recovery capacity and reduce cascading vulnerability under changing disturbance regimes (Messier *et al.* 2019; Aquilué *et al.* 2021; Mina *et al.* 2022).

Objectives. Theme 3 seeks to operationalize FCN across the DIVERSE landscapes by: (1) assessing FCN resilience metrics for each study site; (2) identifying priority areas where diversification, protection, or spatial reconfiguration would most strengthen forest responses to natural disturbances, and (3) developing decision-support tools that allow users to visualize alternative interventions and their expected effects on FCN properties.

Approach. Theme 3 integrates stand inventory and trait information from Theme 1, climate-adapted species groupings from Theme 2, and spatial data describing stand adjacency and dispersal processes to construct functional landscape networks. Network analysis is then used to compute resilience metrics and identify highly central source stands, connectors, and modules, which in turn inform the scenario modelling conducted in Theme 4. The functional metrics will help identify intervention strategies that deliver the greatest improvement in network functioning and recovery potential for a given level of effort, whether at the stand- or landscape-level.

Outputs. Theme 3 will characterize the current state of the DIVERSE study sites with respect to their potential responses to key stressors such as drought and fire. Specifically, it will: (a) identifying stands likely to function as regeneration sources following disturbance; (b) locate areas where connectivity may be weakened under novel conditions and where tree trait diversification could improve recovery potential; (c) identify highly central nodes and connectors where protection, retention, or targeted enrichment could yield disproportionate benefits; and (d) explore how changes in spatial configuration (including modularity and functional zoning) may influence disturbance recovery dynamics and system-wide climate risk propagation. (Aquilué *et al.* 2021; Mina *et al.* 2022).

Theme 4: Scenario Testing with Forest Landscape Simulation Models

Rationale. Forest managers must make decisions despite substantial uncertainty about future climate, disturbance regimes, and socio-economic conditions, while also balancing multiple, and frequently conflicting, management objectives. Forest landscape simulation models provide a way to evaluate the long-term implications of alternative strategies across multiple plausible futures (Scheller *et al.* 2007; Mina *et al.* 2022).

Objectives. Theme 4 aims to: (1) implement the FCN approach within a spatially-explicit forest landscape simulation model (LANDIS-II); (2) compare the long-term performance of BAU, CSF, and FCN strategies under climate change and disturbance scenarios in key DIVERSE sites across Canada; and (3) quantify trade-offs and synergies among key outcomes, including carbon dynamics, wood supply, habitat and biodiversity indicators, and forest resilience metrics.

Approach. Theme 4 uses LANDIS-II and its component extensions for forest growth, succession, disturbance, and management to simulate forest dynamics over long horizons (e.g., up to ~200 years), while incorporating climate-sensitive growth and disturbance processes (Scheller *et al.* 2007; Gustafson *et al.* 2023). Model inputs and calibration are informed by Themes 1–3 and previous studies (e.g., Reese *et al.* 2024), while scenario designs are developed in collaboration with partners to ensure operational realism, including feasible treatments, management constraints, and planning objectives (Sturtevant *et al.* 2007). Scenario results will help prioritize candidate tree species and mixtures for field trials in Theme 6 and will provide quantitative inputs to the technical, socio-economic, and governance assessments of FCN strategies in Theme 5.

Outputs. Deliverables will include documented model configurations, scripts to compare management parameters and scenario outcomes, and syntheses that describe how alternative strategies perform across objectives and uncertain futures. Consistent with Canadian CSF priorities, scenario evaluation will focus on wood supply, carbon storage and sequestration, disturbance-related risks under climate change, biodiversity and habitat outcomes, and water-related indicators. These analyses will make trade-offs and climate change adaptation strategies more transparent and provide a clearer basis for comparing across forest management strategies across sites and scenarios.

Theme 5: Socio-economic Feasibility, Governance, and Implementation Pathways

Rationale. The implementation of BAU, CSF, and FCN strategies is shaped not only by the ecological conditions and silvicultural options, but also by the social dimensions of forest landscapes, including economics, policy, tenure, operational capacity, First Nation rights and collaboration, and broader social values (Williamson and Nelson 2017; O'Neill *et al.* 2025; NCASI 2026). These factors are not merely external constraints on technical solutions; they are integral components of the broader social-ecological system that influence which objectives are prioritized, which interventions are considered appropriate and feasible, and how management outcomes unfold over time. In some jurisdictions, FCN-informed strategies may represent an incremental extension of current practices, whereas in others, they may require a more substantial shift in planning assumptions, administrative processes, and the balance between economically oriented desired future conditions and more ecologically oriented objectives. Understanding these dynamics is therefore essential for translating resilience science into operational guidance that is responsive to local contexts, governance realities, and rights holders.

Objectives. Theme 5 aims to: (1) evaluate the feasibility, costs, benefits, risks, and governance implications of implementing BAU, CSF, and FCN strategies across diverse tenure and management contexts; (2) identify barriers, enabling conditions and trade-offs associated with uptake; and (3) develop implementation pathways and guidance relevant to practitioners, policy makers, rights holders, and other partners.

Approach. Theme 5 integrates socio-economic assessment, governance and policy analysis, and partner engagement to understand how decision context shapes both the definition and adoption of management options. Analyses may include assessments of costs and operational constraints, regulatory fit, tenure rigidity, administrative burden, alignment with policy and certification requirements, and co-produced evaluation of acceptable risk thresholds and trade-offs with partners and rights holders. Findings will feed back into scenario modelling by refining assumptions and constraints, and will also help identify which species, treatments, and intervention pathways are most feasible and appropriate for operational testing in Theme 6.

Outputs. Deliverables will include feasibility guidance, identification of enabling conditions, and recommendations for integrating FCN concepts into existing planning, reporting, and accounting systems. These products are intended to clarify not only what could be done, but what can realistically be implemented under the economic, institutional, tenure, and operational conditions that often shape climate-oriented forest management in practice, including constraints such as regulatory rigidity, administrative burden, workforce capacity, and data gaps (NCASI 2026).

Theme 6: Field Experiments & Operational Learning

Rationale. Confidence in new decision-support approaches depends on demonstrating their performance under real operational conditions, including implementation, monitoring, and iterative learning. Operational field trials are essential for testing how priorities identified through DIVERSE and FCN can be translated into stand-level prescriptions and how those prescriptions perform under practical management constraints (Achim *et al.* 2022).

Objectives. Theme 6 aims to: (1) establish field demonstration sites that implement treatments informed by Themes 1 to 5; (2) monitor regeneration, growth, indicators of forest response, and operational feasibility; (3) support knowledge exchange through field visits, workshops, and practitioner-orientated extension products; and (4) link with complementary national and international initiatives to increase impact, strengthen collaboration, and support cross-walking among indicators, methods, and lessons learned.

Approach. Theme 6 uses a hybrid approach that combines minimum standard treatment and measurement protocols with flexible customization to reflect different forest types, management systems, and operational contexts. Demonstration activities may include establishing multi-species regeneration or enrichment treatments, testing climate-adapted provenances and range-expanding novel tree species, evaluating strategies intended to increase functional diversity and redundancy, comparing alternative harvest and site preparation approaches, and tracking outcomes relevant to both adaptation and mitigation. Monitoring will be aligned, where possible, with partner indicators and reporting needs. It will also provide feedback to improve FCN mapping and scenario design in Themes 3 and 4, to inform feasibility and implementation assessments in Theme 5. Collaboration with aligned initiatives will be used to harmonize selected metrics, share protocols where appropriate, strengthen comparability across jurisdictions, and improve the transferability of results.

Outputs. Deliverables will include a network of demonstration sites, monitoring protocols, and practitioner guidance informed by observed performance and operational experience. Together, these activities are intended to accelerate uptake by providing concrete examples, shared learning, and iterative feedback into DIVERSE tools and planning workflows, while also increasing broader value through coordination with other initiatives.

Box 2. A practitioner workflow for using DIVERSE outputs in forest planning

- **Define the planning context**: Clarify management objectives (wood supply, carbon, biodiversity/habitat, water, and First Nation rights, values, knowledge systems, stewardship priorities, and broader social values), together with relevant constraints and the spatial and temporal scales of interest (SFM/CSF planning cycle).
- **Diagnose current conditions (Theme 1)**: Apply the vulnerability framework and assess its three core components: sensitivity, exposure, and adaptive capacity, in order to identify areas at elevated risk of decline, maladaptation, or regeneration failure.
- **Expand the adaptation portfolio (Theme 2)**: identify climate-suitable species, provenances, and functional groups that can support diversification, assisted migration, and other adaptation options appropriate to local conditions and constraints.
- **Use FCN to prioritize interventions spatially (Theme 3)**: identify priority areas for diversification, stands that function as key sources or connectors for recovery, and opportunities to modify spatial configuration, including modularity, in ways that reduce system-wide risk.
- **Co-design and test management strategies (Theme 4)**: compare BAU, CSF-oriented, and FCN-informed strategies through scenario modelling to evaluate long-term performance, trade-offs, and robustness across multiple ecosystem services under plausible future conditions.
- **Assess implementation conditions (Theme 5)**: evaluate socio-economic costs, governance, tenure, and regulatory constraints; operational capacity; rights-holder priorities; and partnership requirements; identify implementation conditions and collaboration needs.
- **Implement, monitor, and adapt (Theme 6)**: implement field demonstrations and operational trials; track agreed indicators; apply partner- and rights-holder defined decision triggers for re-entry and adjustment; feed learning back into the next planning cycle.

Partnerships and knowledge transfer

DIVERSE is designed as a partnership-driven program in which research questions, scenarios, and decision-support products are co-developed with practitioners, rights holders, and other stakeholders. Governance structures, including a science committee and a steering committee, provide regular forums for collaborative scenario design, data and assumption review, and iterative evaluation of tools and outputs. This co-production model is intended to ensure that DIVERSE products are not only scientifically credible but also operationally relevant across diverse planning contexts, tenures, and objectives.

Knowledge transfer is organized around multiple pathways to support both uptake and learning. These include practitioner workshops to interpret results and refine decision-making processes, field tours and demonstrations to translate concepts into operational prescriptions, and online dissemination of tools, maps, and guidance. Where feasible, DIVERSE outputs will be made available through web-based portals and open-access publications, with project updates and products compiled through the project publication portal. Together, these mechanisms support two-way exchange: practitioners help shape, test, and refine tools, while DIVERSE provides accessible products that can be incorporated into planning cycles, monitoring programs, and adaptive management.

Beyond delivering the datasets, models, analytical outputs, and reports described above, DIVERSE aims to achieve strong integration among its sub-projects by developing and implementing an integration framework. This framework is intended to support the efficient synthesis of high-level findings and actionable recommendations for the wide range of participants in Canada's forest sector, including governments, companies, Indigenous peoples, managers of both working forests and protected areas, environmental non-government organizations, and forest professionals. In doing so, DIVERSE seeks to support these groups in strengthening their understanding of SFM and identifying practical ways to improve the long-term sustainability of Canada's forests under conditions of profound uncertainty and accelerating global change.

Next Steps

Over the remainder of the program, DIVERSE researchers and partners will focus on five interrelated steps. First, they will complete and refine vulnerability assessments. Second, they will operationalize FCN-based prioritization across the study landscapes, identifying priority areas for diversification, protection of key regeneration sources and connectors, and spatial configurations that strengthen recovery while limiting cascading vulnerability. Third, they will test BAU, CSF, and FCN portfolios through scenario analysis to quantify trade-offs and robustness across plausible climate and disturbance futures, explicitly linking results to practitioner objectives and constraints. Fourth, they will evaluate the socio-economic, governance, and implementation dimensions of these strategies to determine which interventions are appropriate, feasible, and scalable across different contexts. Fifth, DIVERSE partners will validate and improve these decision-support products through field demonstrations and implementation assessments, using monitoring and partner feedback to refine assumptions, indicators, and guidance. Collectively, these steps are intended to deliver an evidence-based assessment of when and where, and under what ecological and governance conditions FCN adds measurable value relative to, and where appropriate alongside, CSF-oriented planning, helping the Canadian forest sector target investments, communicate trade-offs transparently, and support forest landscapes capable of sustaining multiple ecosystem services, rights-based priorities, and adaptation options as conditions continue to change.

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Data Availability Statement

This paper describes a research and development program. Data, tools, and publications resulting from DIVERSE will be made available through open-access publications and through the project publications portal, where possible, subject to partner data-sharing agreements and confidentiality constraints (https://diverseproject.uqo.ca/).

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Appendix

Table A1. DIVERSE study landscapes and partners (site-level summary)

Province	Site / ID	Area (ha)	Lead partner/host	Ecozone
BC	Kamloops	36,558	West Fraser	Montane Cordillera
BC	Quesnel	261,468	West Fraser	Montane Cordillera
BC	Babine	3,841,000	British Columbia Timber Sales (BCTS)	Montane Cordillera/Pacific Maritime
BC	Chilliwack	54,000	Ts'elxwéyeqw Tribe Management Limited (TTML)	Pacific Maritime
AB	Peace River East	1,750,000	Mercer	Boreal Plain
AB	Grand Prairie	1,178,018	Weyerhaeuser	Boreal Plain/Montane Cordillera
AB	Blue Ridge	662,200	West Fraser	Boreal Plain
AB	Sundre	582,000	West Fraser	Boreal Plain
SK	Pasquia Porcupine	2,018,073	Weyerhaeuser	Boreal Plain
ON	Kenora	1,137,861	Miisun Integrated Resource Management Company	Boreal Shield
ON	Wabigoon Forest	733,000	Dryden Fibre	Boreal Shield
ON	Pic Forest	1,131,800	Nawiinginokiima Forest Management Corporation (NFMC)	Boreal Shield
ON	White Forest	616,400	Nawiinginokiima Forest Management Corporation (NFMC)	Boreal Shield
ON	Spanish Forest	1,094,000	Interfor/EACOM Timber Corporation	Boreal Shield
ON	Temagami	634,000	Temagami Forest Management Corporation (TFMC)	Boreal Shield
ON	Haliburton Forest	37,000	Haliburton Forest & Wildlife Reserve	Boreal Shield
QC	Rouyn-Noranda	789,430	Chantiers Chibougamau	Boreal Shield
QC	Atikamekw	297,000	Conseil de Bande des Atikamekw	Boreal Shield
QC	Kenauk	25,600	Kenauk Canada	Boreal Shield
QC	Mauricie Region	893,000	Arbec Bois D'Oeuvre	Boreal Shield
QC	Bois Franc	726,000	Agence Forestriere des Bois-Francs (AFBF)	Mixedwood Plain
NS	Western Nova Scotia	1,686,023	Nova Scotia Department of Natural Resources	Atlantic Maritime