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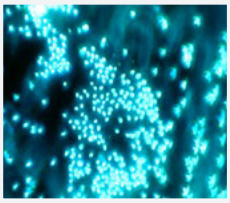
In Brief

from the Canadian Forest Service – Laurentian Forestry Centre

Number 64 - 2025






Spruce budworm: Understanding its interactions with wildland fires

The spruce budworm (SBW) is a major source of disturbances in the boreal forests of eastern Canada. Despite their significant effect, these biotic disturbances have rarely been incorporated into Dynamic Global Vegetation Models (DGVM), which are typically used to estimate the global impacts of climate change on terrestrial ecosystems, particularly wildland fires. It has also been suggested that these disturbances may increase the likelihood of fires in affected regions.

With this in mind, a research team made up of members of the Ontario Forest Research Institute, *Université de Lorraine, Université de Montpellier*, UQAT, University of Hong Kong, PSL University and the Canadian Forest Service have developed a model to represent spruce budworm defoliation and its influencing factors, on a regional scale, within a DGVM.

Photo: NRCan

The team devised a method for representing the SBW development cycle within a DGVM in relation to foliage density, larvae density, and their defoliation effects. Additionally, an experiment was conducted to examine the interactions between SBW and wildland fires. Findings indicated that the area burnt slightly increases following an outbreak, though this dynamic could be influenced by climate change. The study concluded that the SBW model could be adapted to other defoliator insect species and that biotic disturbances and their interactions with wildfire can be effectively simulated within a DGVM.

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Scarified and amended soil: Ideal conditions for sugar maple?

The sugar maple has long been a dominant species in the forests of southeastern Canada and the northeastern United States. Recent studies have shown that extreme events such as drought, pest outbreaks, and soil acidification have an impact on deciduous forest composition in certain regions. For example, species of lower economic value, such as beech, are gradually encroaching on sugar maple stands under these new conditions.

To encourage sugar maple growth and limit that of beech, several methods have been employed, including creating canopy gaps, calcium amendment (lime, wood ash), soil scarification, and removal of beech, albeit with limited success. In search of new solutions, researchers from the Canadian Forest Service compared the effect of three soil amendments, in combination with or without scarification, on hardwood regeneration in a mature sugar maple-dominated stand subjected to selection cutting. The goal was to identify the combination that would promote high-value species, such as sugar maple and yellow birch, while limiting the growth of secondary species.

The study results demonstrate that lime amendment promoted the growth of sugar maple while controlling beech and red maple, whereas scarification particularly promoted the growth of yellow birch, pin cherry and red maple. When combined, scarification and lime amendment have proved effective in supporting sugar maple recovery, enabling the re-growth of yellow birch and pin cherry, and controlling beech and red maple.

The effectiveness of treatments and their combinations highlights the importance of considering the specific needs of different species when fine-tuning forest composition.

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Using geographic variation in the adaptive evolution of trembling aspen to address climate change

Improving climate resilience predictions on plant species that are essential to ecosystem stability—particularly to natural habitat restoration—is a considerable asset in the context of climate change. Trembling aspen (a.k.a. quaking aspen) plays a crucial role in the study of resilience to future climate conditions, as it ensures the maintenance of various ecosystem functions.

This study introduces a novel framework for climate-resilient revegetation based on genetic variation patterns in trembling aspen. Through germination trials, the genetic structure and composition of over 1,000 individuals across the species' North American range were analyzed. This approach delineated four major genetic groups across the North American range.

Geographical distribution of aspen samples used in the study (Photo: NRCan)

This study also highlighted varying responses of natural populations of trembling aspen from the western United States and eastern Canada when exposed to high temperatures and water stress. For example, under drought conditions, genotypes from the western United States exhibited significantly lower germination rates compared to those from eastern North America. Genome regions associated with variations in temperature and precipitation were identified, potentially explaining these differences.

These findings give us a better understanding of the adaptive potential of this key species, whose presence is in constant decline in the western parts of its range, particularly in Mexico. Such insights could form the basis for climate-resilient revegetation initiatives in the future.

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This publication is part of a series that presents popularized summaries of scientific articles written in whole or in part by Laurentian Forestry Centre researchers.

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Exploring the evolutionary origins of antifreeze proteins using the genome of the spruce budworm

Insects have developed various mechanisms to survive winter conditions. Among freeze-intolerant species, certain produce antifreeze proteins that bind to nascent ice crystals, inhibiting their growth (proliferation). This mechanism enables the spruce budworm (SBW) to withstand temperatures as low as -30 °C. Despite the potential significance of antifreeze proteins in the adaptive diversification of this species, little was previously known about their evolutionary origins. Using a comparative genomics approach, a multi-institutional scientific team set out to better understand the evolution of genes encoding these antifreeze proteins in SBW.

Photo: NRCan

Initial analyses identified nine new genes encoding antifreeze proteins in the larvae. The research also highlighted the early diversification of this gene family, with most genes observed as close relatives of the *Choristoneura* genus. Although the antifreeze proteins of this insect were previously thought to be unique to this genus, the results also revealed seven similar genes in a distantly related species, *Notocelia uddmanniana.* The high structural similarity between the antifreeze proteins of these two species strongly suggests a shared evolutionary origin. The discovery of similar genes in other insects within the same family suggests that these genes have ancient origins.

These findings hold great promise for a broad range of investigations into fundamental questions about the biology of SBW or the creation of new, targeted control tools for managing this pest.

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Earthworms alter the microbiome of forest soils

The invasion of North American forests by exotic earthworms can have a significant impact on soil microbial communities by modifying the soil's physicochemical properties. While most research in this area has focused on temperate forests, what effects might there be in hemiboreal and boreal forests, where organic matter decomposition is notably slower?

A team composed of researchers from the University of Alberta, Mount Royal University and the Canadian Forest Service set out to find out more. They analyzed and compared microbial communities in both the organic and mineral soil layers of forest soils that were either invaded or not invaded by exotic earthworms. To do so, they collected samples from three common Canadian forest soil types: Brunisols, Podzols and Luvisols.

The results indicate that in organic layer, the effects of earthworm invasion are minimal. In mineral soil layers, earthworm invasion is associated with increased fungal biomass and greater microbial diversity. In these layers, bacteria adapted to nutrient-poor environments are less prevalent in invaded soils, while the opposite is observed for bacteria adapted to rich environments. These changes were observed in all three soil types, indicating the robustness of earthworm-related effects linked to earthworm colonization in these ecosystems that were initially devoid of earthworms. Given the essential role of soil microbial communities in ecosystem functioning, such changes may alter nutrient cycling, vegetation development, and, consequently, forest productivity on a larger scale.

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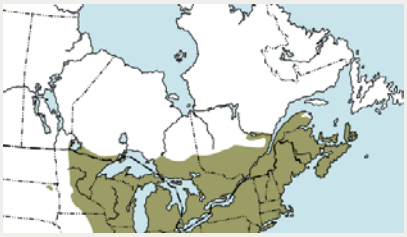
Sugar Maple: Declining at the northern edge of its range

Since the 1980s, heat waves, drought, frost, acid deposition, and insect defoliation—which all reduce photosynthetic activity—have been suggested as contributors to declining sugar maple growth in the southern parts of its range. A team of scientists aimed to better understand how these factors are impacting sugar maple growth in the northern regions of its distribution.

To investigate, a retrospective growth index dating back to 1950 was developed based on annual growth ring widths in sugar maples from sites in Quebec and Ontario. The model used takes into account tree age and size, terrain elevation, slope, competition and climatic factors. The results of the study suggest significant geographic variations in growth trends in sugar maples. For example, growth decline is notably present at the northern boundary of the species' range, while it is less pronounced in the central study area. Additionally, analyses reveal that sugar maple growth is negatively correlated with summer vapour pressure deficit, a measure of atmospheric drought.



Area of sugar maple distribution (Photo: NRCan)

As such, climate change may hinder the northward expansion of the sugar maple's range. Any decline in this species' growth could have significant impacts on forest productivity and ecosystem services, underscoring the importance of implementing adapted silvicultural practices to support sugar maple growth.

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