

# **Prioritizing conservation of trailing-edge populations for future climate-resilient forests**

Nicholas Boyce<sup>1\*</sup>, Andreas Hamann<sup>1</sup>, Genevieve Dorrell<sup>1</sup>, & Scott E. Nielsen<sup>1</sup>

*(Extended abstract with figures and tables of a manuscript in submission. Please contact the corresponding author for more details)*

1: Department of Renewable Resources  
Faculty of Agricultural, Life, and Environmental Sciences  
University of Alberta  
751 General Services Building  
Edmonton, AB, Canada, T6G 2H1

\* Corresponding author's contact information: [nboyce@ualberta.ca](mailto:nboyce@ualberta.ca)

Running title: Conserving trailing-edge tree populations

Acknowledgements: This research was funded in part by the DIVERSE Project Canada and MITACS.

Keywords: Genetic conservation, conservation planning, climate change, assisted migration, adaptive management, forest management

Word count: 5464 (Abstract – Acknowledgements)

## Extended Abstract

Trailing-edge tree populations, located at the warm or dry margins of species' distributions, represent potential reservoirs of adaptive genetic variation under climate change. These populations have evolved under climatic stress and may contain traits relevant for future forest resilience. However, they are also among the first to experience climate conditions that exceed historical tolerances, creating an immediate conservation need.

Here, we provide a spatially explicit assessment of trailing-edge populations for the 100 most common North American tree species, integrating climate analog modeling, forest inventory data, and ecosystem-level analyses to identify priorities for conservation and assisted migration. We used an ecosystem-based climate matching framework to compare historical (1960s) and projected future (2050s) climates across 2270 delineated ecosystem units. Trailing-edge populations were identified where projected declines in climate suitability intersected with the warmest or driest portions of each species' range.

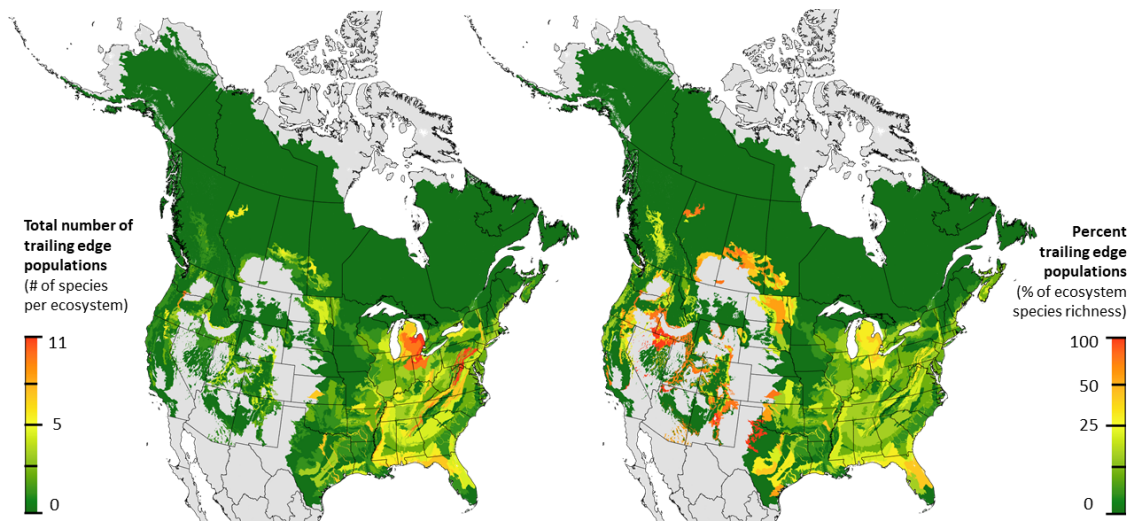
The spatial distribution of these populations reveals distinct geographic patterns of conservation concern. Absolute concentrations of at-risk populations are highest in the Appalachian Mountains and Great Lakes region, reflecting high species richness, whereas relative risk is elevated in southern boreal–temperate transition zones and lower montane systems (Fig. 1). These contrasting patterns distinguish areas of high conservation value from areas of high proportional vulnerability.

To prioritize conservation action, we evaluated three complementary risk dimensions: projected forest cover loss, climate velocity, and species richness of trailing-edge populations. Forest cover loss, interpreted as exceeding fundamental climatic limits for tree growth, is most pronounced in the southwestern boreal forest and western margins of eastern temperate forests (Fig. 2, left). Climate velocity, indicating the distance required for populations to track suitable climates, is highest across the central plains and adjacent regions (Fig. 2, right). The risk factors often co-occur in relatively species-poor landscapes, suggesting that conservation priorities should not be based solely on biodiversity hotspots. Jurisdiction-level summaries highlight provinces and states where combined risks are highest, providing a direct link to policy and resource allocation (Fig. 3).

We further evaluated opportunities for conservation by identifying ecosystems that could serve as recipient areas for assisted migration. Demand for incoming populations is concentrated in the Great Lakes region, northeastern United States, and parts of eastern Canada, where future climates align with historical conditions of many trailing-edge populations (Fig. 4, left). Capacity, measured as climatically suitable habitat within protected areas, generally aligns with demand, indicating that existing conservation networks can support assisted migration strategies in many regions (Fig. 4, right). However, mismatches between demand and capacity in parts of western North America highlight limitations of current protected area distributions, highlighted in jurisdictional summaries (Fig. 5).

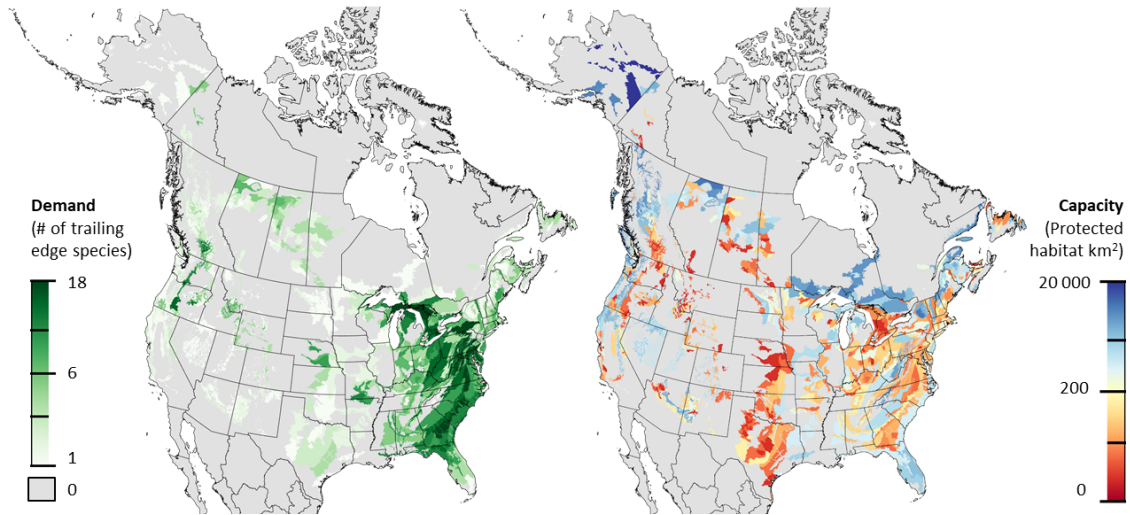
To operationalize these findings, we developed the Protected Area Selection Tool for North America (PAST-NAM; <http://tinyurl.com/PAST-NAM>), which allows users to identify climatically suitable recipient sites for populations of concern. The tool applies the same multivariate climate matching approach at the ecosystem level and provides a practical interface for integrating conservation planning with ongoing reforestation and restoration activities.

Overall, our results support a shift in conservation focus toward landscapes where high climate velocity and projected habitat loss coincide, particularly in the Midwest and southwestern boreal forest. In contrast, mountainous regions with lower climate velocity may allow for short-distance persistence through elevational gradients. These findings argue for a dual strategy: conserving high-value trailing-edge populations *in situ* where feasible, while incorporating them into assisted migration and reforestation programs elsewhere. By linking spatial prioritization (Figs. 1–5) with an operational tool, this study provides a practical approach for maintaining the adaptive capacity and long-term resilience of North American forests under climate change.

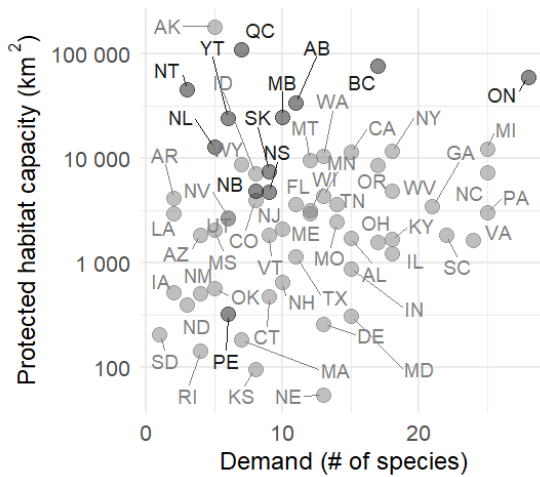


**Figure 1.** Trailing edge tree populations at warm or dry range margins that are at heightened risk due to climate change. **Left:** The total count of at-risk populations as number of threatened species in each ecosystem. **Right:** Climate threat as the proportion of at risk species to all study species in the ecosystem.





**Figure 4.** Projected demand and capacity for incoming assisted migration of trailing-edge populations at risk. **Left:** Demand quantified as the number of species with climate-threatened trailing edge populations for which the ecozone is projected to provide suitable climatic habitat under 2050s conditions. **Right:** Capacity for accepting assisted migration within ecosystems with demand. Capacity is measured as the projected area of protected forest (km<sup>2</sup>) under the 2050s forest cover scenarios. Ecozones with no demand have been excluded and are represented in grey.



**Figure 5.** Jurisdictional summary of projected demand and capacity for assisted migration. Canadian provinces (darker shades) and US states (lighter shades) are plotted by the number of threatened species projected to find suitable climate habitat (demand) and the area of protected forest projected for the 2050s (capacity, in log<sub>10</sub> km<sup>2</sup>). Jurisdictions in the upper right combine high demand with high capacity, suggesting opportunities to use and conserve trailing-edge populations as part of their climate change adaptation strategies.