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

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Abstract

Trailing edge tree populations, located at the warm or dry margins of species' ranges, often harbor unique genetic adaptations to marginal environments. These populations face heightened risks from climate change, potentially threatening the persistence of valuable adaptive traits. Here we identify trailing edge populations for the 100 most common North American tree species using spatially explicit climate and forest inventory data, prioritizing action based on projected forest cover loss, climate velocity, and species richness. Assisted migration initiatives for these populations could safeguard the long-term persistence of their adaptive traits, ensuring that valuable genotypes are maintained within future forest ecosystems. Trailing edge populations were geographically concentrated in the Appalachian region, the Midwest, and southern boreal forests. Areas bordering the central plains faced the highest projected forest cover loss and climate velocity, while the Great Lakes basin and eastern Canada emerged as promising recipient regions. Our findings support targeted conservation and assisted migration strategies to maintain genetic diversity and enhance forest resilience under future climates, facilitated by an online tool for climate-informed seed collection and planning (http://tinyurl.com/past-nam).
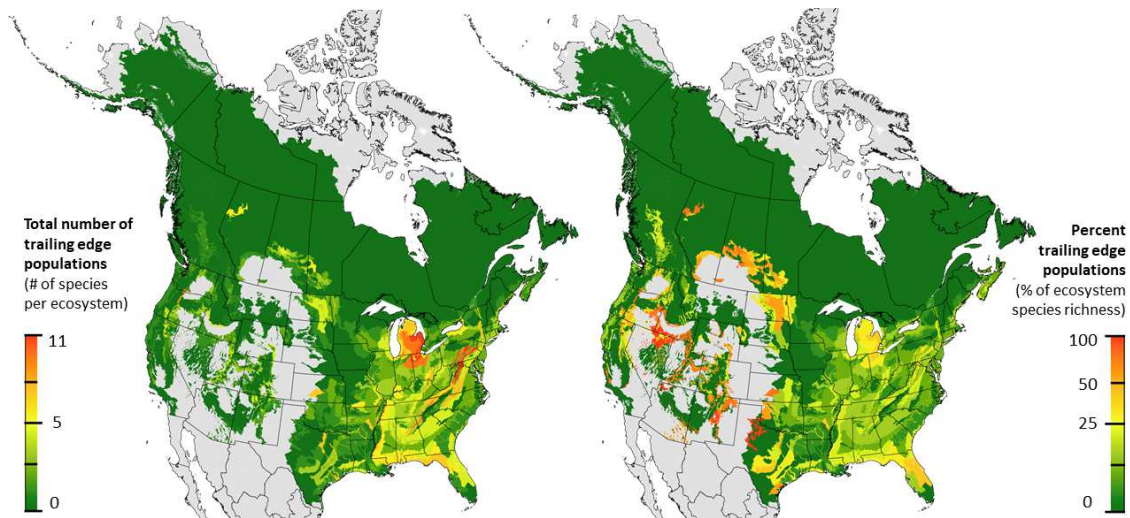
Figure 1. Trailing edge tree populations at warm or dry range margins that are at heightened risk due to climate change. **Left:** The total count of at-risk populations as number of threatened species in each ecosystem. **Right:** Climate threat as the proportion of at risk species to all study species in the ecosystem.
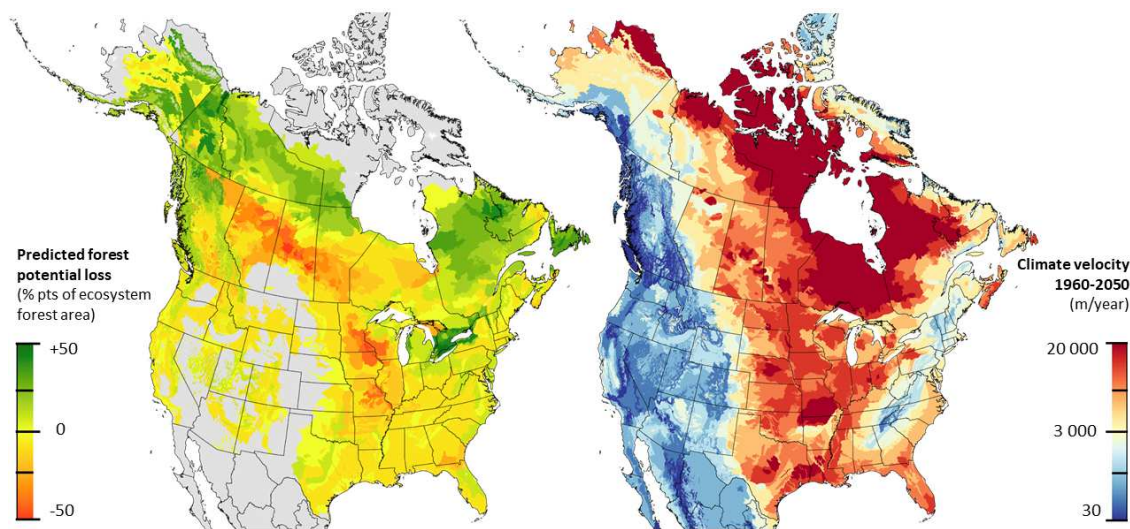

Figure 2. Climate-related risk factors for prioritizing gene conservation collections. **Left:** Projected forest cover loss between the 1960s and 2050s, indicating regions where climatic conditions may exceed the physiological limits of forest tree species. **Right:** Climate velocity (m/year), representing the distance populations must shift annually to remain within their historical climate envelope, and highlighting areas where natural migration may be insufficient.
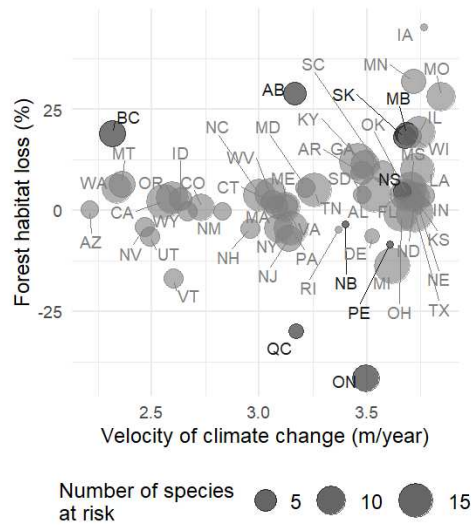
Figure 3. Near-future climate risks for genetic diversity, aggregated by jurisdictions. Canadian provinces (darker shades) and US states (lighter shades) in the upper right face the largest projected forest cover loss by the 2050s (indicating fundamental niche limits for all species are exceeded on a portion of their land base) and the highest climate change velocity values (indicating the need for human intervention). The responsibility of jurisdictions with regard to conservation values is represented by the size of circles.
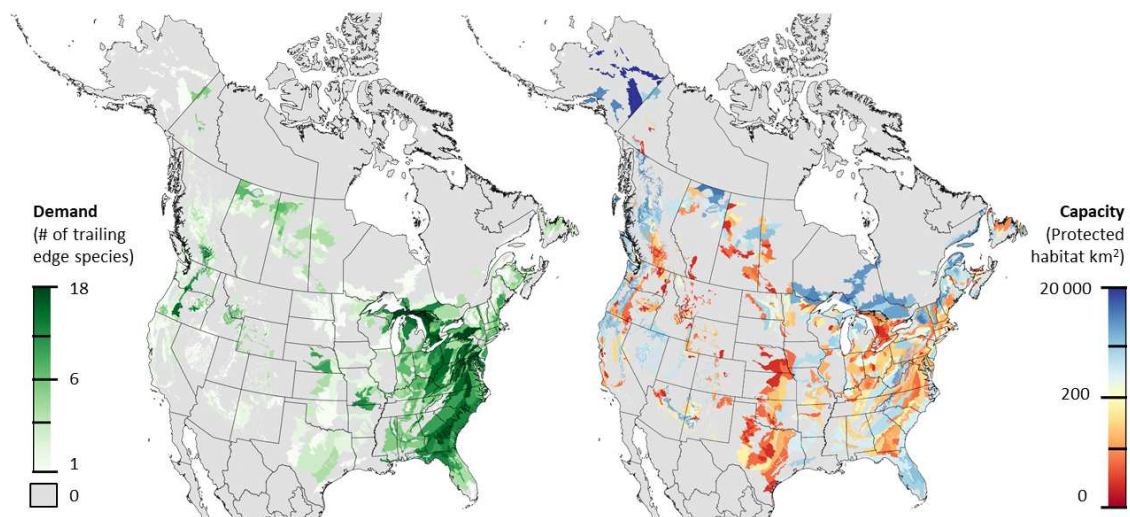

Figure 4. Projected demand and capacity for incoming assisted migration of trailing-edge populations at risk. **Left:** Demand quantified as the number of species with climate-threatened trailing edge populations for which the ecozone is projected to provide suitable climatic habitat under 2050s conditions. **Right:** Capacity for accepting assisted migration within ecosystems with demand. Capacity is measured as the projected area of protected forest (km²) under the 2050s forest cover scenarios. Ecozones with no demand have been excluded and are represented in grey.
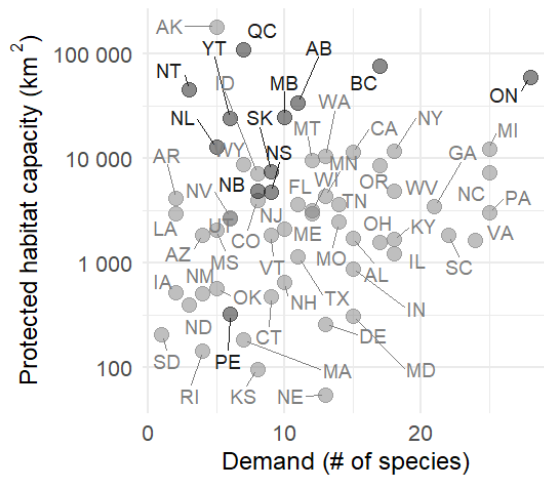
Figure 5. Jurisdictional summary of projected demand and capacity for assisted migration. Canadian provinces (darker shades) and US states (lighter shades) are plotted by the number of threatened species projected to find suitable climate habitat (demand) and the area of protected forest projected for the 2050s (capacity, in $\log_{10}$ km²). 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.