Guidelines for Assisted Migration and Seed Movement in the Eastern United States

Carolyn C. Pike

Overview:

- We are synthesizing literature from genetics trials for 11 major tree taxa native to the Eastern United States for a new guidebook to help managers make decisions related to seed transfer. This guidebook will complement knowledge contained in the Climate Change Atlas (Peters et al. 2020). Two chapters were recently prepublished for jack pine (Pike 2021a) and white spruce (Pike 2021b). Longleaf and shortleaf pine will also be included.
- Yellow birch, white spruce, black spruce, red oak, eastern white pine, and red pine can tolerate transfer distances of 200–300 miles, from south to north. This distance corresponds to a mean annual temperature (MAT) that is 5–7 °F (2–4 °C) cooler. Black walnut and sugar maple should not be moved in excess of 200 miles (5 °F, 2.2 °C), and jack pine should be kept locally with distances not to exceed 100 miles (3.6 ˚F, 1.5 ˚C), especially in the Lake States. MAT estimates for these distances are based on Frenne et al. (2013).
- A new set of seed zones for the eastern United States (ESZF) can be used for assisted migration: Managers can transfer seed from one seed collection zone to the south (from warmer climate) without exceeding 200-mile (5.4 °F, 2.2 ˚C) transfer distances in most locations.
- Eastern Seed Zones (ESZF) were recently added to the Seedlot Selection Tool to help managers identify future climate analogues.

Summary:

Forest managers in the eastern United States need to decide which species and seed sources will be best adapted to current and future climates. This guidebook will synthesize information on genetics, silviculture, and forest health to assist land managers on decisions to seed transfer for major tree species in the eastern U.S.

Silvicultural Concepts:

- The rapid pace of climate change will likely exceed the rate of historical range shifts of native trees.

- Managers are encouraged to plant nonlocal seed sources to improve adaptation in the future, but this practice poses inherent risks to the plantings' success.
- The impact of insects and diseases on future forests are difficult to predict, but their impact may be buffered by using sources with genetic diversity that are adapted to current and future climates.
- Seed sources that are moved too far from their origin may be inadequately synchronized with conditions at the planting site. This asynchrony is likely to be expressed as premature leaf-out in the spring, delayed bud-set in the fall, or low growth rates that result in competitive exclusion.
- In hardwoods, hybridization with related species may alter future phenotypes with unpredictable consequences. These hybridization events may be accelerated or slowed depending on phenology and placement of species in the future.

Management Applications:

- Planting nonlocal seed sources should be done carefully by considering current and future projected climate conditions.
- Forest trees in the eastern U.S. can generally tolerate long-distance movement of seed, but managers need to watch for signs of poor adaptation. These clues may be manifest as premature leaf out or delayed bud-set. Asynchrony of leaf senescence, in hardwoods, is also a sign that a planted seed source is poorly synchronized with conditions at the site.
- Forest managers are encouraged to employ online tools, such as the Seedlot Selection Tool, to identify areas with future climate analogues. Managers are also cautioned that transfer distances that are required to match future analogues may exceed transfer recommendations for different taxa.

References:

Frenne, P.; Graae, B. et al. 2013. Latitudinal gradients as natural laboratories to infer species' responses to temperature. Journal of Ecology. 101: 784–795.

Peters, M.P.; Prasad, A.M.; Matthews, S.N.; Iverson, L.R. 2020. Climate change tree atlas, version 4. Delaware, OH: U.S. Department of Agriculture, Forest Service, Northern Research Station and Northern Institute of Applied Climate Science. https://www.nrs.fs.fed.us/atlas. (March 2021).

Pike, Carolyn C. 2021a. Jack pine: Guidance for seed transfer within the Eastern United States. Tree Planters' Notes. 64(2): 26–32.

Pike, Carolyn C. 2021b. White spruce: guidance for seed transfer within the Eastern United States. Tree Planters' Notes. 64(2): 19–25.

Table 1—Summary table of genetics and forest health concerns for conifers native to the Eastern United States. "Favorable" traits are those that are most likely to improve survival under future conditions.

Conifers	Black spruce, *Picea mariana*	White spruce, *Picea glauca*	Jack pine, *Pinus banksiana*	Red pine, *Pinus resinosa*	White pine, *Pinus strobus*
Genetic diversity	High	High	High	Low	High
Gene flow pollen/seed	High/high	High/high	High/med	High/med	High/high
Primary pests of concern	Spruce budworm, *Choristoneura fumiferana*; dwarf mistletoe, *Arceuthobium pusillum.*	Spruce budworm, *Choristoneura fumiferana.*	Eastern gall rust, *Cronartium quercuum;* jack pine budworm, *Choristoneura pinus.*	*Heterobasium annosum*, *Diplodia* spp.	Blister rust, *Cronartium ribicola.*
Favorable traits	High genetic diversity, mixed cone serotiny, shade tolerant.	High genetic diversity, highly plastic, shade-tolerant.	Drought tolerant, serotinous cones, fire-adapted.	Highly planted, fire-tolerant.	Broad ecological amplitude, high genetic diversity, shade tolerant.
Unfavorable traits	Relatively slow-growing.	Pests can build up in even-aged stands.	Shade intolerant. Gall rust may become more widespread in the future.	Low genetic diversity, susceptible to several pathogens.	Emerging new pests and pathogens. High sensitivity to air pollutants.

Table 2—Summary table of genetics and forest health concerns for hardwoods native to the Eastern United States. "Favorable" traits are those that are most likely to improve survival under future conditions.

Hardwoods	Red oak, *Quercus rubra*	Yellow birch, *Betula alleghaniensis*	Sugar maple, *Acer saccharum*	Black walnut, *Juglans nigra*
Gene flow pollen/seed	High/moderate	High/high	High/moderate	High/high
Hybridization potential	Hybridizes with other species in the red oak group.	Hybridizes with paper birch where ranges overlap (Lake States).	May hybridize with black maple where ranges overlap.	Does not readily hybridize.
Primary pest of concern	Forest tent caterpillar, *Malacosoma disstria*; *Armillaria* spp.	Bronze birchborer, *Agrilus anxius.*	Forest tent caterpillar, *Malacosoma disstria*; *Armillaria* spp.	Anthracnose, *Gnomonia leptostyla;* thousand cankers disease, *Geosmithia morbida.*
Favorable traits	High genetic diversity. Tolerates a range of site types.	High seed production, small, winged seeds. Few pests.	High seed production, high shade tolerance.	High seed dispersal, high genetic variation.
Unfavorable traits	Prone to defoliation. Shade- and drought-intolerant.	Natural regeneration limited by stringent seed bed requirements.	Low tolerance to drought.	Low tolerance to drought. Relatively shade intolerant.