Genetic Considerations for Assisted Migration Efforts: Northern Hardwoods

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EXTENDED ABSTRACT

Forest managers historically sought locally sourced seed for planting to ensure that future forests were adapted to local conditions. As the climate warms, managers are increasingly seeking seed from more southerly locales. This movement of seed from outside the local seed zone, known as assisted migration, is one of several silvicultural tools being enacted to improve the resilience and adaptation of forests in the future (Williams and Dumroese 2016). A variety of strategies to implement assisted migration have been proposed (Breed et al. 2013, Havens et al. 2015, Potter and Hargrove 2012, Vitt et al. 2010). Genetic considerations can help inform which strategy is most likely to succeed, but resources for northern hardwood trees are scarce. The objective of this presentation is to update managers on existing knowledge from genetics studies related to northern hardwood trees. Secondly, I will describe how to incorporate the Seedlot Selection Tool and the new eastern seed zones (Pike et al. 2020) into an assisted migration plan.

Four genetic considerations should be considered before assisted migration is undertaken: knowledge of safe seed transfer distances, risks of outbreeding depression, potential to enhance insect/disease outbreaks, and risks of hybridization. The effects of long- and short-distance seed transfer have been extensively studied in progeny and provenance trials established across North America in the 20th century as part of an organized tree improvement effort on commercially valuable conifers. Information on the genetics of most northern hardwood species and other noncommercial species is largely deficient. Provenance trials that were established for northern red oak (*Quercus rubra* L.), yellow birch (*Betula alleghaniensis* Britton), and sugar maple (*Acer saccharum* Marsh.) are being reassessed to help inform assisted migration efforts (Leites et al. 2019). These studies have limited inference space because few gardens were planted and most are located within the central portion of the species ranges; extreme sites, and therefore extreme transfer events, were not tested. Transfer distances of 100 to 200 miles (from south to north) are well tolerated by jack pine (*Pinus banksiana* Lamb.) (Thomson and Parker 2008), a species with conservative transfer recommendations. In the absence of empirical data, a conservative approach (100 to 200 miles) is likely to be well tolerated by most northern hardwoods.

Studies of population genetics assess genetic diversity on neutral (noncoding) DNA are useful to quantify the historical migration and inbreeding for a species. These studies have revealed that most tree species are highly heterozygous owing to the extensive movement of seeds and pollen across the landscape (Hamrick et al. 1992). The genetics of several hardwood species have been studied, including sugar maple, yellow birch, and red maple (*Acer rubrum*). These northern hardwood trees have high levels of genetic variation and high gene flow (Thomson et al. 2015) in some cases at levels comparable to conifers (Jones et al. 2006). This latent heterozygosity implies that outbreeding depression is not a likely consequence from assisted migration of northern hardwood trees. Small-statured native plants, with limited seed dispersal, are more likely to experience outbreeding depression (Jones et al. 2006) and should be moved with caution.

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Many hardwood tree species are capable of interspecific hybridization which is often undetected because offspring from a hybrid cross may resemble either parent (Crystal et al. 2016). For example, northern red oak (*Quercus rubra*) readily hybridizes with other species in the red oak (Lobatae) group (Aldrich et al. 2003); yellow birch and paper birch (*Betula papyrifera* Marshall) hybridize in the Lake States (Barnes et al. 1974, Thomson et al. 2015); and butternut (*Juglans cinerea* L.) frequently hybridizes with Japanese walnut (*Juglans ailantifolia* Carrière) (Hoban et al. 2009). Seed sources with a hybrid pedigree, that result from a cross between species with diverse cold tolerances, may lack sufficient hardiness when transferred northward, although no studies have confirmed this outcome. For example, managers in Wisconsin who acquire seed from Indiana may inadvertently acquire seed with a hybrid pedigree that includes the more southerly shumard oak (*Q. shumardii* Buckley). These hybrid seeds may lack the cold tolerance needed to survive in the upper Great Lakes, but managers have few options other than to weed out seedlings that are poorly adapted or to identify seed sources with lower rates of hybridization.

Assisted migration may exacerbate existing pest or pathogen complexes especially if trees are planted outside their existing range in a range-expansion effort. For example, the movement of northern red oak to northern climates, where red oak is uncommon or absent, may inadvertently introduce eastern gall rust (*Cronartium quercuum* (Berk.) Miyabe ex Shirai), a major pest on jack pine that requires oak as an alternate host (Anderson 1970). In general, moving southern seed sources to northern locales within the existing range is a safer recommendation than range expansion. Future studies that quantify the interactions of pests and pathogens with translocated seed sources are needed to inform managers of potential risks (King 1971). Studies are also needed to better understand phenology (Lu and Man 2011), inherent physiological differences of novel seed sources (Bansal et al. 2015), and other ecological constraints (Winder et al. 2011) that result from seed movement. Northern hardwood trees, in general, should be resilient to the effects of assisted migration because of their inherent genetic diversity and life history traits that promote high gene flow. New seed transfer guidelines, which include a summary of genetic considerations, are being developed for publication in the near future.

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