
Climatic change and assisted migration: Strategic options for forest and conservation nurseries

by Mary I. Williams and R. Kasten Dumroese

In light of current studies (for example, Gray and Hamann 2012; Zhu and others 2012) that show climate will change faster than plants can adapt or migrate naturally, it begs the question, “What does this mean for forestry, specifically forest and conservation nurseries?” Growing trees that just survive may become more important than promoting fast growth rates for superior genetics (Hebda 2008). In a recent survey of state and commercial nurseries in the US, most state nurseries have not explored how changes in climate will impact their abilities to select, produce, and provide trees that are suitable to projected climatic conditions (Tepe and Meretsky 2011).

Although we focus more on trees and reforestation in this article, the discussion and concepts we present are applicable to all native plants — trees, because of their long-lived status, pose special circumstances for assisted migration.

Land managers are being advised to acknowledge climate change predictions in their reforestation plans, but uncertainty about predictions, current client demands, and existence of current plant transfer guidelines constraint active measures (Tepe and Meretsky 2011). The practice of restricting native plant movement to environments similar to their source has a long history in forest management (Langlet 1971), however, transfers must now factor in climate change because plant materials guided by current guidelines and zones will likely face unfavorable growing conditions by the end of this century. Seed transfer guidelines and zones are used to determine the safest distance that a population can be moved to avoid maladaptation (Johnson and others 2004). To facilitate adaptation and migration, we will need to modify transfer guidelines in the direction of climatic change – to suit target tree species and populations. This is going to require more information than we currently have, but now is the time to address the issue.

So where do we go from here?

Adaptive strategies such as assisted migration are an option for some tree populations. From a forestry perspective, we have been properly moving trees for a long time, by using seed transfer guidelines. Assisted migration takes this one step further; it is the movement of species and populations to facilitate natural range expansion in a direct management response to climate change (Vitt and others 2010). This does not necessarily mean moving plants far distances, but rather helping genotypes, seed sources, and tree populations move with suitable climatic conditions to avoid maladaptation (Williams and Dumroese 2013). We can avoid the inclination to use foreign plant materials just because they grow well (Hebda 2008), we are not at that point yet. Evaluating species that might naturally migrate is an option. For example, in Canada, Alberta anticipates that future climatic conditions might be suitable for growing ponderosa pine (*Pinus ponderosa*) and Douglas-fir (*Pseudotsuga menziesii*) that currently grow near the province but are now absent in the province (Pedlar and others 2011).

Movement of populations to sites that are climatically suitable for growth and productivity at some point in the future is a challenging component of assisted migration (Pedlar and others 2011; Potter and Hargrove 2012). For a species or population, this may entail moving seed across seed-zone boundaries or beyond transfer guidelines (Ledig and Kitzmiller 1992). Methods using transfer functions and provenance data have been developed to guide seed movement under climate change (for example, Beaulieu and Rainville 2005). Online tools are available to assist forest managers and researchers in making decisions about matching seedlots with outplanting sites and seed transfer. The Seedlot Selection Tool (Howe and others 2009) is a mapping tool that matches seedlots with outplanting sites based on current or future climates for tree species such as Douglas-fir and ponderosa pine and Seedwhere (McKenney and others 1999) can map out potential seed collection or outplanting sites based on climatic similarity of chosen sites to a region of interest. Preliminary work in Canada on most commercial tree species

demonstrates that target migration distances would be short, occurring within current ranges (O'Neill and others 2008; Gray and others 2011). For some tree species, target migration distances are < 125 miles north or < 328 ft up in elevation during the next 20 to 50 y (Beaulieu and Rainville 2005; O'Neill and others 2008; Gray and Hamann 2012; Pedlar and others 2012).

Whilst having to fulfill client demands in current forestry plans and efforts, it will be difficult for nurseries to plan for future demands. With some collaboration, however, we can shift the focus to producing plant materials that grow and survive by modifying past and current projects and implementing studies and strategies. Many existing projects, such as provenance and common garden studies can be transformed with little modification to look at adaptation and response to climatic conditions (Matyas 1994). Information such as where the plant comes from, where it is planted on the site, and how it performs (growth, survival, reproduction, and so on) can guide nursery practices to increase the proportion of species that survive and grow well (McKay and others 2005; Millar and others 2007; Hebda 2008). Nurseries can work with geneticists to explore genotypes that may be resilient to temperature and moisture extremes. The target plant concept (Landis et al. 2010), culturing of stock types for specific outplanting goals and objectives, can be employed to identify and propagate plant materials from hot and dry extremes of a species range. Using disturbed areas as outplanting sites to test assisted migration is a perfect opportunity to also evaluate genotypes, seed mix diversity, and age classes (Spittlehouse and Stewart 2003; Millar and others 2007; Jones and Monaco 2009), although this may mean that nurseries carry tree species that may not be presently native to the outplanting site.

Assisted migration may not be appropriate for every species or population. Establishment of healthy stands is vital now to prepare forests before major changes occur. Further, there is little point in planting the standard species or stocks in regions highly sensitive to climate change (Hebda 2008). Reductions in fire frequency from 100 to 300 y to 30 y, for example, have the potential to quickly shift some forest systems to woodlands and grasslands (Westerling and others 2011), thereby negating the objective to plant trees and instead shifting the focus on other plant species to establish. By 2100, an estimated 55% of landscapes in western US may exhibit climates that are incompatible with vegetation ecosystems occurring there today (Rehfeldt and others 2006).

Because the frameworks and techniques for production and outplanting already exist, forest nurseries can work with researchers and practitioners to start the ball rolling and hopefully curtail significant social, economic, and ecological losses associated with impacts from a rapidly change climate. Changing policies will require collaboration and discussion of how predicted conditions will affect forests, how nurseries can plan for the future, and how clients can be encouraged to plant trees adapted to future conditions, such as warmer conditions and variable precipitation patterns (Tepe and Meretsky 2011). Fortunately, many state nurseries, especially in the eastern half of the US, already carry tree species and seed sources collected from sites further south (often beyond state borders) than the anticipated outplanting sites, suggesting that plant materials being planted now may be adapted to warmer conditions.

Whatever the chosen adaptive strategies, forest and conservation nurseries need to be included in the dialogue for climate change planning. The science and practice of growing trees and other native plants to sustain ecosystems will greatly benefit by increased collaboration between practitioners and researchers (McKay and others 2005). A challenge will be determining when demand for these climate-adapted/assisted migration candidates will occur (Hebda 2008), but nurseries and researchers can prepare for potential demand by broadening their capacity, increasing expertise, and experiment with different genotypes and seed sources.

References

- Beaulieu J, Rainville A. 2005. Adaptation to climate change: Genetic variation is both a short- and a long-term solution. *The Forestry Chronicle* 81:704-709.
- Gray LK, Hamann A. 2012. Tracking suitable habitat for tree populations under climate change in western North America. *Climatic Change* 117:289-303.
- Gray LK, Gylander T, Mbogga MS, Chen P, Hamann A. 2011. Assisted migration to address climate change: Recommendations for aspen reforestation in western Canada. *Ecological Applications* 21:1591-1603.
- Hebda RJ. 2008. Climate change, forests, and the forest nursery industry. In: Dumroese RK, Riley LE, eds. *Forest and Conservation Nursery Associations, proceedings, 2007*. Fort Collins (CO): USDA Forest Service, Rocky Mountain Research Station. General Technical Report RMRS-P-57:81-82.

- Howe GT, St. Clair JB, Beloin R. 2009. Seedlot Selection Tool. URL: http://sst.forestry.oregonstate.edu/contact_us.html (accessed 9 Jul 2013).
- Johnson GR, Sorensen FC, St. Clair JB, Cronn RC. 2004. Pacific northwest forest tree seed zones: A template for native plants? *Native Plants Journal* 5:131-140.
- Jones TA, Monaco TA. 2009. A role for assisted evolution in designing native plant materials for domesticated landscapes. *Frontiers in Ecology and the Environment* 7:541-547.
- Landis TD, Dumroese RK, Haase D. 2010. Seedling processing, storage, and outplanting, Volume 7, *The Container Tree Nursery Manual*. Washington (DC): USDA Forest Service. Agriculture Handbook 674. 192 p.
- Langlet O. 1971. Two hundred years genecology. *Taxon* 20:653-721.
- Ledig FT, Kitzmiller JH. 1992. Genetic strategies for reforestation in the face of global climate change. *Forest Ecology and Management* 50:153-169.
- Matyas C. 1994. Modeling climate change effects with provenance test data. *Tree Physiology* 17:797-804.
- McKay JK, Christian CE, Harrison S, Rice KJ. 2005. "How Local Is Local?" - A review of practical and conceptual issues in genetics of restoration. *Restoration Ecology* 13:432-440.
- McKenney DW, Mackey BG, Joyce D. 1999. Seedwhere: A computer tool to support seed transfer and ecological restoration decisions. *Environmental Modelling* 14: 589-595. Available at: URL: <https://glfc.cfsnet.nfis.org/mapserver/seedwhere/seedwhere-about.php?lang=e> (accessed 9 Jul 2013)
- Millar CI, Stephenson NL, Stephens SL. 2007. Climate change and forests of the future: Managing in the face of uncertainty. *Ecological Applications* 17:2145-2151.
- O'Neill GA, Ukrainetz N, Carlson M, and 8 others. 2008. Assisted migration to address climate change in British Columbia—recommendations for interim seed transfer standards. Victoria (BC): British Columbia Ministry of Forest and Range, Research Branch. Technical Report 048.
- Pedlar J, McKenney DW, Beaulieu J, Colombo S, McLachlan JS, O'Neill GA. 2011. The implementation of assisted migration in Canadian forests. *The Forestry Chronicle* 87:766-777.
- Pedlar J, McKenney DW, Aubin I, and 6 others. 2012. Placing forestry in the assisted migration debate. *BioScience* 62: 835-842.
- Potter KM, Hargrove WW. 2012. Determining suitable locations for seed transfer under climate change: a global quantitative method. *New Forests* 43:581-599.
- Rehfeldt GE, Crookston NL, Warwell MV, Evans JS. 2006. Empirical analysis of plant-climate relationships for the western United States. *International Journal of Plant Science* 167:1123-1150.
- Spittlehouse DL, Stewart RB. 2003. Adaptation to climate change in forest management. *BC Journal of Ecosystems and Management* 4:1-11.
- Tepe TL, Meretsky VJ. 2011. Forward-looking forest restoration under climate change - are US nurseries ready? *Restoration Ecology* 19:295-298.
- Vitt P, Havens K, Kramer AT, Sollenberger D, Yates E. 2010. Assisted migration of plants: Changes in latitudes, changes in attitudes. *Biological Conservation* 143:18-27.
- Westerling AL, Turner MG, Smithwick EAH, Romme WH, Ryan MG. 2011. Continued warming could transform Greater Yellowstone fire regimes by mid-21st century. *Proceedings of the National Academy of Science, Ecology, Environmental Sciences* 108:13165-13170.
- Williams MI, Dumroese RK. 2013. Preparing for climate change: Forestry and assisted migration. *Journal of Forestry* 111: in press. URL: <http://dx.doi.org/10.5849/jof.13-016> (accessed 8 Jul 2013).
- Zhu K, Woodall CW, Clark JS. 2012. Failure to migrate: Lack of tree range expansion in response to climate change. *Global Change Biology* 18:1042-1052.