Guidelines for Implementing Assisted Migration of Plants on Agency Lands

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Assisted Migration
Findings and Recommendations for Agency of Natural Resources Lands

In 2015, the Agency of Natural Resources Lands Team appointed a small group to review information on the climate change adaptation strategy known as assisted migration and present recommendations for implementing on lands owned and managed by the Agency of Natural Resources. The Work Group members were: Robert Popp and Robert Zaino, F&W; Lisa Thornton, Nancy Patch and Sandy Wilmot, FPR.

The ANR Assisted Migration Work Group explored literature, information from federal and state organizations, and local expertise to determine the full scope of considerations around the topic of assisted migration involving plants. This work does not address animals, nor does it specifically address genetically modified organisms. These recommendations are for forest species, and although focused on ANR Lands, we include broad information as background for consideration on private lands and for Use Value Assessment forest plans.

Background Information on Assisted Migration

Species are adapted to specific combinations of environmental and climate conditions that allow them to grow, thrive and reproduce. When climate changes reduce suitable habitat, species are forced to either acclimate to the new conditions (adapt), move (migrate) to areas where suitable habitat still exists, or become locally extirpated. Forest trees are long-lived and normal migration is slow. **During the last ice age, it is estimated that species migrated very slowly, at a rate of about 0.1 to 0.5 kilometers (0.06-0.31 miles per year). To keep pace with shifting climate and to be able to regenerate under suitable habitat conditions, trees would need to migrate at a rate of at least 6-10 kilometers per year (3.7-6 miles per year).**

One controversial strategy is the human-aided relocation of species. **A recent review on the topic found that 60% of published articles generally support consideration of assisted migration, while 20% are opposed, and 20% remain undecided**. Supporters point to the possible extinction of species without assisted migration, while critics point to the lack of guaranteed success, the possible unintended consequences, and historical dangers of introducing species to new habitats.

Assisted migration is typically defined as the human assisted movement of species beyond their historic ranges. However, this document is broader in scope and encompasses assisted population migration and augmentation which are not strictly considered to be assisted migration since both techniques entail movement or planting that is within the historic or current range of the species. Additional terms used in the literature are *translocation, assisted colonization,* or *managed relocation.* All of these require intentionally moving plants, and is not the same as silvicultural manipulations that favor one species over another.

Definitions for assisted migration vary and make a difference in how information and recommendations will be interpreted. The terms and definitions that best match our dialogue:

Assisted migration: The human-assisted movement of species in response to climate change. This is the overarching term that includes several types of species movement.

> ***Assisted population migration*** (Assisted gene flow): The human-assisted movement of individual plants or seeds within the species established range to preserve the breadth of genotypes for adaptation to climate change. This builds resilience within a population by augmenting populations within the current range.
>
> ***Assisted range expansion***: The human-assisted movement of species to areas just outside their established range in response to climate change, facilitating or mimicking natural range expansion. Seed zone maps are often used to identify region of provenance[1].
>
> ***Assisted long-distance migration***: The human-assisted movement of species to areas far outside their established range (beyond areas accessible via natural dispersal) in response to climate change.

The reasons for implementing assisted migration vary, and include two main goals:

1. ***To maintain functional ecosystem services*** – Maintain forest productivity and ecosystem services; aims to ensure that forests will be climatically adapted for the duration of the rotation; defined broadly to include maintaining wildlife habitat, erosion prevention, watershed protection, carbon uptake, etc. This is often separated into two categories: preserving ecological processes (e.g. carbon cycle) and preserving economically-important species.

   General conclusions:
   - Much less controversial than assisted migration for species rescue (described below)
   - Planting of different provenances has been happening for centuries
   - Primary goal is maintaining flow of ecosystem services
   - Includes movements within and slightly beyond the current species ranges
   - Ecosystem/forestry and species rescue assisted migration are not mutually exclusive (i.e. American chestnut)

2. ***To rescue species from extinction***– Preserve genetic diversity; movement of isolated, at risk populations to more hospitable environments.

   General conclusions:
   - Natural systems can be dynamic and traditional natural resource management must have legal flexibility to respond
   - Contemporary natural resource management laws that adhere to historic baselines of plant composition and geographic distributions, protecting pre-existing biota, and shielding nature from human activity is increasingly being questioned.
   - Other considerations include whether to:
     - prioritize protection of endangered species likely to lose habitat under climate change or focus on conserving native biota in situ;

[1] Seed zone maps have been developed for western states, and are currently in development for eastern states. A **seed zone** (also called a region of provenance) of a species is defined as the area or groups of areas, subject to sufficiently uniform ecological conditions, in which stands show similar phenotypic or genetic characters are found (OECD, 1974).

- manage ecological systems so as to predetermine their future composition or leave nature to self-adapt and accept the consequence;
- manage resources to promote their fitness for future conditions or preserve resources as they exist today.

An example of species rescue is the effort to prevent the extinction of Florida torreya *(Torreya taxifolia**),*** endemic to a small area in Florida, now being grown in natural settings throughout the country by a volunteer group whose purpose is to prevent species extinction. Work with this species provides many guidelines, successes and failures to review about assisted migration decisions and techniques. http://www.torreyaguardians.org/learnings.html

The table below summarizes the benefits and liabilities associated with assisted migration.

Benefits and Merits	Risks and Liabilities
• Maintains ecosystem functions • Preserves ecosystems and communities in rapid decline • Protects vulnerable species from maladaptation and extinction • Maintains ecosystem health and economic viability • Maintains genetic diversity	• Establishment of new invasive or weedy species (not native to transplanted location) • Adverse effects on local communities at transplant site • Loss of local genotype and within-species self-adaptation • Contrary to goal of preserving natural ecosystems and processes • Cost of time and resources to implement

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Table 1. Assisted migration - Intentional translocations

The following table is intended as a framework for discussions on assisted migration as a climate change strategy for forest species.

Types of assisted migration	Purpose	Examples	Merits	Liabilities
Within current range – Movement of a species from one location to another within current range.	• Increase abundance of species identified as benefiting from climate projections. • Expand locations for optimum growth as site conditions change • Maintain forest overstory or forest connectivity.	• Increase abundance of climate-adapted species like red and white oak • Restore floodplains with silver maple, sycamore or bur oak plantings • Plant white pine and red spruce to replace hemlock • Plant in critical riparian migration corridors or headwaters	• Increase species abundance for future forest. • Increase seed source on the landscape. • Improve chances of maintaining ecosystem services (habitat, wood, forest cover, flood resiliency). • Provide for connectivity on fragmented landscape. • Has been done for centuries.	• Climate projections and species responses are uncertain. • May use planting stock or seed source from outside Vermont. • May unintentionally move pests or invasive species. • Potential for hybridization. • Over-reliance on artificial regeneration could have negative effects on ecosystem functions.
Outside current range - Intentional movement of species, populations or genotypes to a location outside their historical distribution	Climate projections identify southern species more suitable to future conditions, or characteristics of a certain provenance that may tolerate adverse weather conditions.	• Fraser fir to replace balsam fir in frost pockets due to its later budbreak. • American chestnut in northeastern Vermont, outside historic range.	• Improve chances of maintaining ecosystem services (habitat, wood, forest cover, flood resiliency). • Helps species move across ecological barriers in a fragmented landscape.	• Climate projections and species responses are uncertain. • May unintentionally move pests or create invasions. • Time honored conservation practice disrupted. • Unintentional negative consequences for destination ecosystem. • Lack of jurisdictional precedent. • Risks increase with distance.
Developed landscapes - Introduction of a species and management to ensure successful establishment.	Ornamental species planted in residential or urban locations.	• Shagbark hickory planted in northern VT • Tulip poplar, magnolia, horse chestnut; all native species but outside its range	• Long history of ornamental plantings. • Successful planting trials. • Climate-resilient, non-invasive species introduced for passive expansion. • Import system is in place.	• Unintended consequences. • Potential for hybridization. • May unintentionally move pests or create invasions. • Regulatory organizations overworked, so high risk of negative outcome.
Species rescue - Moving rare, threatened, and endangered species to new locations.	• Preserve genetic diversity of species at risk. • Prevent extinction of globally or regionally rare species or narrow endemics.	Moving rare, threatened and endangered species to new locations.	• Traditional management may not be enough. • Few other options available.	• Saving a species may compromise ecosystem integrity. • May unintentionally move pests or create invasions • Potential for hybridization • High cost with uncertain success

Guidelines for Assisted Migration on ANR Lands

The guidelines identified in this document are based on our current understanding of climate change impacts on species in Vermont as well as the current science on assisted migration. As climate projections and/or assisted migration science advance, it is expected that this "tiered options" framework for assisted migration strategies can be revised to reflect the urgency of moving species for climate adaptation.

The guidelines presented in this document are intended to be used at the operational level, with district stewardship teams identifying and reviewing possible sites to consider the feasibility of assisted migration of plants. Existing long-range management planning assessments, such as the natural community assessment, timber assessment, wildlife habitat assessment, and water resources assessment should be used to assess site conditions and vulnerabilities needed to make decisions. If assisted migration of plants is proposed, it should be noted in the relevant project in the district's annual stewardship plan

Before considering assisted migration options, other climate change adaptation strategies are recommended for use on Agency lands. (Horton, 2015)

There are currently no scenarios where it is appropriate for human-assisted intentional movement of species (plants or seeds) into new areas on Agency lands from **long-distance species relocation** (Tier 5). This includes new plantings into Vermont and Vermont species relocated into other states or provinces.

These guidelines identify scenarios where it is appropriate for human-assisted intentional movement of species (plants or seeds) into new areas **within their current range and/or into new areas adjacent to their current range** (Tiers 2-4).

These guidelines identify special considerations needed for S1 and S2 natural communities and species, and for some S3 species and natural communities (Tier 1-3). *See Appendix for descriptions of S1-S5, State Rankings for Species and Natural Communities*.

The choice of species to plant on Agency lands should consider species that are predicted as climate-adapted to the planting location. Locally sourced plants and seeds are recommended as a first choice for all plantings on Agency lands.

Climate Change Adaptation Strategies on Agency Lands

Before addressing details of the assisted migration recommendations, additional adaptation strategies for climate change should be considered. Adaptation strategies are identified in the Forestry Division document for building resilient forests: "Creating and maintaining resilient forests in Vermont: Adapting forests to climate change". Landscape level adaptation can be achieved through the "Vermont Conservation Design":

For S1 or S2 species or natural communities

1. Maintain these species/communities as self-adapting. If justified, augment existing plants to maintain viable populations.
2. Maximize biodiversity and physical landscape diversity, enduring features, and movement corridors.
3. Identify refugia for species and manage to maintain populations.
4. Assisted migration is not recommended.

For S3 species or natural communities

1. Manage these species and natural communities as self-adapting or with some assisted migration within current natural community associations.
2. On a case-by-case basis, such as where declines are anticipated due to climate change or pest damage (e.g. ash), resilient species not within the current natural community association may be planted.
3. Increase abundance of species expected to do well with climate change by planting in appropriate sites. Maintain some of current species along with planted climate winners.
4. Leave some natural community examples unaltered as examples of self-adaptation.

For S4 and S5 species or natural communities

1. When they occur within well-connected forest blocks or old forests—features expected to have high resilience—S4 and S5 species and natural communities should be allowed to self-adapt.
2. For all other S4 and S5 species and natural communities, adaptation strategies will vary according to each parcel, however, long-distance intentional assisted migration is not recommended at this time.

In the future, State Land may be the appropriate planting location to rescue southern species. However, if this is considered, it should require adequate review by the appropriate District Stewardship Team and VFWD Natural Heritage Inventory, and advice from the appropriate Scientific Advisory Group (SAG) of the Endangered Species Committee.

Assisted Migration Strategies on Agency Lands

General Guidance

1. Focus on encouraging native plants associated with current natural communities, well suited to a particular site. Climate change impacts in the short-term (less than a harvest rotation length) are not expected to alter natural community associations over this time frame.
2. Include representative natural communities without manipulation in statewide planning as self-adaptation reference sites.
3. Only consider assisted migration range expansion when there is a need for tree planting, either as restoration forestry, as part of a harvest, or in anticipation of future declines.
4. State lands long-range management plans should include consideration of each of the tiered recommendations (below) to identify appropriate locations (if any) for each type of assisted migration.
5. State lands annual work plans that include plantings should consider selecting tree species that are expected to be adapted to climate change.
6. While seeds may be less expensive, success rates are generally better when seedlings are planted.
7. Monitor outcomes to inform future assisted migration.

Assisted Migration Options

When intentional human-assisted migration is being considered on Agency lands, selection of the appropriate option can be facilitated using a 5-tier selection process from most passive (Tier 1) to most active (Tier 5). Below are the 5 tiers of assisted migration options, followed by further explanation (Table 2).

- No assisted migration, self-adaptation (Tier 1)
- Moving plants or seed within current range, using local sources, and keeping within current natural community associations (Tier 2). Although not recommended at this time, this would include moving species within their current range, but from a seed source outside of their range, to enhance genetic diversity.
- Moving plants or seed within current range, using local sources, but altering natural community associations (Tier 3)
- Moving plants or seed into new areas, using local sources, that expand the edge of range (Tier 4)
- Moving plants or seed into new areas from long-distance species relocation (Tier 5)

Selecting the Appropriate Option for Agency Lands Planning

Step 1. **Are there S1 or S2 species or natural community considerations**?

Use Tier 1. Maintain these communities, use resistance adaptation strategies, and if justified, augment existing plants to maintain viable populations.

Step 2. **Are there S3 species or natural community considerations**?

Use Tier 1 or 2, except where species are significantly disrupted by climate change or pest activity, then use Tier 3 on a case by case basis. When planting occurs try to select species expected to be adapted to future climate conditions.

Step 3. **Are these S4 and S5 species or natural communities**?

These ecosystems are common, Tier 1-4 is possible.

Tier selection depends on site conditions and species characteristics to determine the potential for self-adaptation vs other adaptation strategies.

Tier 1 is recommended for:

- Forests that are well-connected with other forest blocks, making self-adaptation more likely to occur.
- Old forest stands are thought to be more resilient and should be left unmanaged.

Tier 2 -4

- The appropriate tier will need to be considered for each parcel using criteria listed in Table 2.
- Locally sourced seeds or plants that are within current range are preferred.

Tier 5. Not recommended for use on State Land at this point in time. As climate change impacts advance, this could be reconsidered, but would need to be justified using the best science available.

Table 2. Descriptions and Applications of Assisted Migration Options for Agency Lands

Tiered Options for Assisted Migration Assisted migration options from most passive (Tier 1) to most active (Tier 5)					
	Tier 1	**Tier 2**	**Tier 3**	**Tier 4**	**Tier 5**
Description	**No assisted migration, self-adaptation**	**Moving plants or seed within current range using local sources and within current natural community associations**	**Moving plants or seed within current range using local sources but altering natural community associations**	**Moving plants or seed into new areas using local sources that expand the edge of range**	**Long-distance species relocation by moving plants or seed into new areas**
Selection criteria	▪ For connected landscapes that allow species to move as a self-adaptation strategy ▪ To maintain S1 and S2 natural communities as self-adaptable	▪ To increase abundance of species expected to do well with climate change ▪ To repopulate sites with climate adaptable species	▪ In anticipation of declines due to climate change or pest damage (e.g. ash)	For plantings in developed areas including landscaping and residential rather than planting in the wild	▪ Rescuing southern species by moving to VT ▪ GMO plants, if considered, would be included in this tier
Implementation	▪ Maximize biodiversity and physical landscape diversity, enduring features, and movement corridors ▪ Identify species refugia to ensure site is not degraded by invasive species or other disturbances	▪ Maintain some of current species along with planted climate "winners" ▪ Leave some natural community examples unaltered as reference sites	▪ Choose species that are expected to be adapted to climate change ▪ Leave some natural community examples unaltered as a control	Choose species that are expected to be adapted to climate change	▪ Not recommended at this time ▪ For future implementation, controlled conditions and rigorous scrutiny should be in place before attempting this and long-term monitoring should be included

Examples of assisted migration decisions for Agency Lands.

1. Large patches of green ash mortality are found adjacent to a wetland, not due to EAB, but requiring riparian plantings. Due to the future potential for emerald ash borer infestations an alternative species for re-planting is needed. Consider non-ash species that are climate-winners based on future projections. Riparian species for these situations may be silver maple or bur oak. (Tier 3)

2. A State Park adjacent to State Forest land in southern Vermont wants to increase tree diversity as a way to build resilience. Tulip poplar, a southern species considered a climate-winner, is just outside its northern limits here, so would be a range expansion if planted. The forests here are S5, with no known S1 or S2 species. Planting a few trees in the park would be appropriate to diversify and include a southern climate-adapted species. Planting acres of tulip poplar in the middle of the State Forest would be too risky (more liability than merit) and would not be appropriate. (Tier 4)

3. Red oak is a common species in Vermont, but not abundant in some hardwood forests. Your management plan for a northern hardwood forest, S5 natural community, calls for increasing species diversity, especially because white ash is the predominant species. There is currently no red oak growing in the forest. It would be appropriate to diversity the stand by planting red oak, a climate-winner, as part of the future forest. Planting seedlings rather than acorns has a better likelihood for success, and getting planting stock from a local nursery reduces risks of importing unwanted pests. (Tier 2 or 3)

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Appendix

State Ranking of Species and Natural Communities

These recommendations are based on the state ranking of native species and natural communities that characterize relative rarity (abundance) or endangerment within Vermont's geographic boundary, as follows:

S1 - Very rare (Critically imperiled): At very high risk of extinction or extirpation due to extreme rarity (often 5 or fewer populations or occurrences), very steep declines, or other factors
S2 - Rare (Imperiled): At high risk of extinction or extirpation due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors
S3 - Uncommon (Vulnerable): Moderate risk of extinction/extirpation due to restricted range, relatively few populations or occurrences (often 80 or fewer), recent and widespread declines, or other factors
S4 - General, regular, and apparently secure: May be locally uncommon or widely scattered but not uncommon on a statewide basis
S5 - Common (Secure): widespread and abundant

Planting Materials Available or Used in Vermont

Provenance

Planting materials of known provenance is key to assisted migration. According to the OECD, "a **seed zone** (also called a region of provenance) of a species is defined as the area or groups of areas, subject to sufficiently uniform ecological conditions, in which stands showing similar phenotypic or genetic characters are found" (OECD, 1974). Seed zone maps are often used to identify region of provenance. Seed zone maps have been developed for western states, and are currently in development for eastern states.

Some genetic mixing within native species may be beneficial to species adaptability. Historically, tree provenance trials were done all over the state. Records of these trials are scattered throughout state records and scientific literature but are not readily available.

Live Plants

The VT Agency of Agriculture, Food and Markets regulates nurseries, which are described as a dealer purchasing, selling or installing live plants. All nurseries must be licensed, and the Agency of Agriculture maintains an online database of nurseries. Nurseries are inspected annually to prevent the movement of economically damaging pests (plant pathogens, insects, mites, and noxious weeds). There are currently 2 starter nurseries, 38 production nurseries, 8 nurseries that sell nut trees, and 47 sources of tree material in Vermont (https://usaplants.vermont.gov/USAPlants/Licenses/PlantMerchantSearch.aspx).

The Green Mountain National Forest 2006 Forest Plan includes standards for tree improvement plantings. "When planting or seeding is needed to meet resource objectives, the stock will be genetically

diverse and of local origin from Vermont or New Hampshire. Collections from stands or seed production areas that will be used for reforestation should include seed from a minimum of 15 parents. Evaluation plantations that achieve genetically diverse samples of species gene pools and provide information that is useful for development of seed movement or global climate change research should be protected and maintained. These include yellow birch, sugar maple, butternut and American chestnut."

The Green Mountain National Forest obtains planting stock from a nursery in Watersmeet, MI, which also supplies all National Forests in the 20 northeastern states. They have a local seed orchard and can also use seed sent to them.

The Natural Resource Conservation Service supports restoration plantings using stock from federal nurseries. One nursery in Corning, NY, provides plant material for New England, New York and Pennsylvania. Currently, the only tree species listed as available for planting are native willows.

ANR District Offices working with partners at The Nature Conservancy and the Natural Resources Conservation Districts use locally sources plants when available, but must also rely on plants from a nursery in Michigan.

Tree plantings in yards, street trees, parks, and other community locations often use stock from outside Vermont. The Vermont Urban and Community Forestry Program has recently responded to the lack of local planting materials by providing technical guidance to communities for establishing community tree nurseries: http://vtcommunityforestry.org/resources/tree-care/community-tree-nurseries. Some successful plantings of trees from well outside of the current hardiness zones are known to occur, e.g. black walnut, tulip poplar, magnolia, catalpa, horsechestnut.

Seed

Sale and transport of seeds for planting is regulated by the Agency of Agriculture, Food and Markets. Tree and shrub seeds covered by Vermont's Seed Standard Regulations must meet label requirements, including information about origin.

Sources of tree seed in Vermont are difficult to identify, but include the following suppliers: *The Sheffield Seed Company, Tree Seeds, The Tree Center, Vermont Willow Nursery, The Tree Center, Intervale Conservation Nursery, and Plant Restoration Nursery at Green Mountain College.*

Word of mouth advertising of local oak acorns successfully distributes acorns to foresters statewide.

Assisted Migration Policies from Other States, Provinces, Organizations

British Columbia

The majority of forestland in this province is publicly owned land, and is reforested manually following harvests. Starting in 2008, the Province created a policy to allow range expansion of seed of Douglas-fir and other species 200 meters higher in elevation than current populations, and one seed zone further north (up to 300 kilometers or 2 degrees of latitude). Standards were amended to allow planting western larch in some areas outside of its current range of occurrence, up to 10% of the species mix in new plantings. Since 200 million seedlings are planted each year, the government saw a need to act to build resilient future forests for future economies.

Oregon

Assisted migration should be considered as an alternate management during reforestation. Climate change should be a consideration in forest management plans to address change in species composition, refugia for threatened and endangered species.

Alberta

Seed transplants can advance 200 m in elevation or 2^{o} latitude (ca. 140 miles).

Quebec

Allows planting of more southern species as part of a mix with local species.

US Forest Service

There must be evidence of success before implementing assisted migration (https://www.fs.fed.us/nrs/pubs/jrnl/2013/nrs_2013_johnson_001.pdf)

New England Wildflower Society, purpose is to prevent plant extinction:

1. Managed relocation should be considered, as part of an overall strategy using the best science available for each species, case by case.
2. Prioritization of endemics/near endemic species most vulnerable to climate change would be researched as potential targets.
3. Most likely scenario is that New England will be a recipient of plants from southern areas.