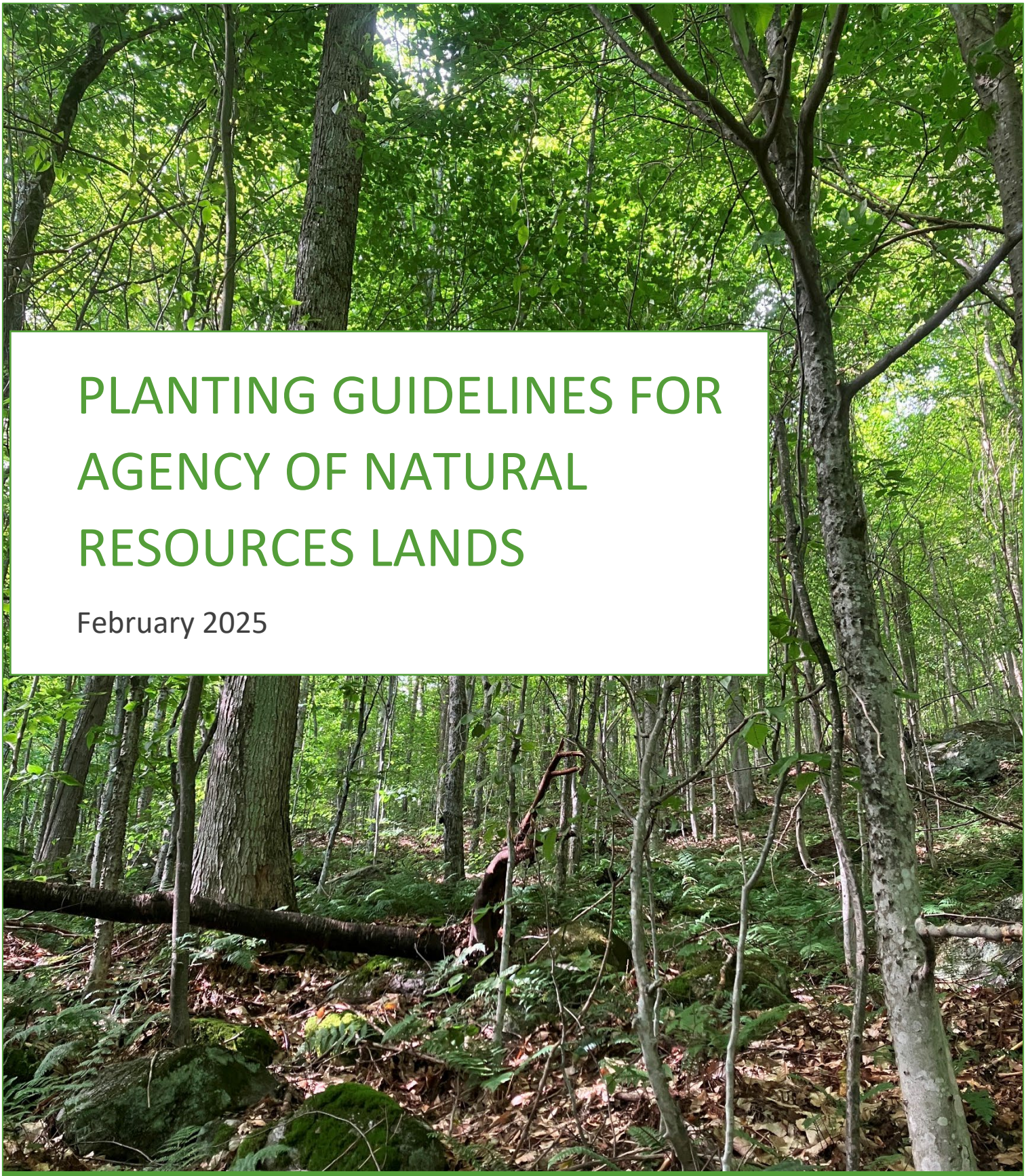

PLANTING GUIDELINES FOR AGENCY OF NATURAL RESOURCES LANDS

February 2025

Vermont Agency of Natural Resources Lands Guidance Document

2025

VERMONT
AGENCY OF NATURAL RESOURCES

Planting Guidelines for Agency of Natural Resources (ANR) Lands:

Vermont ANR Lands Guidance Document

Signed by:

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Julie Moore, Secretary
Vermont Agency of Natural Resources

2/25/2025

Date

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Planting Guidelines for Agency of Natural Resources Lands

Background & Statement of Need

In 2022, a workgroup from the Agency of Natural Resources (ANR), supported by the ANR Lands Team and including representatives from the Departments of Forests, Parks, and Recreation (FPR) and Fish and Wildlife (FWD), initiated a review of the *2017 Assisted Migration Guidelines for Plants on Agency Lands* (Popp, Zaino, Patch, Thornton, & Wilmot, 2017). The goal was to ensure the guidelines were aligned with the latest research on assisted migration and climate adaptation. During this review District Stewardship Team staff from all three Agency departments provided feedback advocating that all planting projects on Agency lands should be considered under a similar lens.

In response, the *Planting Guidelines for ANR Lands* were developed into a single, cohesive document to provide a guide for the most common planting project types on state lands. These guidelines provide clear instructions for the review and evaluation of planting projects, reflecting the collective input from Agency staff. While we acknowledge that project goals can vary widely across different management activities, this document serves as a foundational framework and addresses the need for overarching guidance. These guidelines can be adapted and refined to develop more specific recommendations tailored to varying objectives and project outcomes. A broad-based approach ensures a streamlined and standardized process for all planting projects for herbaceous, shrub, and tree species on state lands and is the first of its kind.

These guidelines aim to increase the use of native plants in proposed projects while providing specific guidance for different project types, such as climate and pest and pathogen adaptation, ecosystem restoration, research, landscaping, and erosion control. ANR manages nearly 360,000 acres of state-owned land, and across these diverse holdings, planting projects provide an opportunity to increase biodiversity of existing ecosystems and to improve overall habitat quality and forest health across Vermont.

Additionally, a changing climate and subsequent shifts in climate regimes require ANR to think broadly about what plants are most likely to thrive and meet long-term goals. To account for the uncertainty around adaptability to novel stressors, these guidelines empower Agency staff to manage state lands as complex adaptive systems, to maintain and enhance structural and compositional diversity and redundancy across multiple temporal and spatial scales, and support multiple ecosystem services, including carbon sequestration and storage, cultural and aesthetic values, water filtration, natural community assemblages, and more. These opportunities can be achieved differently depending on project goals and focus, while supporting ANR's mission to preserve, enhance, restore, and conserve Vermont's natural resources for the benefit of current and future generations.

Finally, the Agency is regarded as a model of land stewardship by both partners and the public. It is important that Agency lands exemplify best practices to inspire and guide others, thereby promoting the adoption of these practices on a statewide scale.

Guideline Objectives

These guidelines are designed to be dynamic, with timely periodic reviews to incorporate the latest scientific advancements. They are grounded in robust scientific research, drawing extensively on studies and recommendations from our agency and a wide array of organizations, including the United States Forest Service, National Park Service, Plant Conservation Alliance, Native Plant Trust, University of Vermont, and the United States Fish and Wildlife Service, among others. These guidelines reflect the diverse landscapes of ANR lands and encompass the full spectrum of public uses and management objectives for these areas.

The primary objectives of these guidelines are to:

- Protect and enhance native biodiversity and ecosystem function.
- Protect genetics of locally adapted plant species and populations.
- Avoid introduction of non-native invasive plants, pests, and pathogens.
- Provide guidance on adaptation plantings to address novel stressors such as climate change, pests, and pathogens.
- Provide a framework/tool for project development and review.
- Raise awareness and educate ANR staff on best practices for successful planting projects.

These guidelines will help ANR state land managers on District Stewardship Teams navigate decision-making for planting projects on state lands, while also providing transparency to the public about ANR's expectations for protecting and enhancing biodiversity and ecological resilience on Agency-owned and managed lands as planting projects are implemented.

Applying the Guidelines

These guidelines apply to ANR-owned lands, including those areas licensed for approved uses by other entities, as well as ANR lands where timber rights are held by other entities. Lands under lease agreements are encouraged to follow these best practices. Additionally, these guidelines offer best practice guidance for private lands under conservation easements held by the Agency.

The guidelines are intended to be applied within the context of and consistent with other guiding management documents including management plans, Agency or Department land management policies, guidelines and procedures, departmental missions and purposes of land ownership, and legal constraints, such as conservation easements and deed restrictions. These guidelines are not intended for use in Section 248 or Act 250 proceedings, which require applicants to follow separate, established channels of review within those respective processes.

There may be instances where these guidelines cannot be fully applied, such as in areas licensed for agricultural use, where the management goal is crops, grazing, or hay production. In projects involving erosion control and developed areas like roadsides and state park entrances, alternatives to using only native plants are sometimes included. However, native plantings in these developed settings can be successful and provide valuable habitat for native pollinators and other wildlife.

Definitions

Terminology

1. **Assisted Migration** (AM) – Assisted migration is the deliberate movement of plant species by humans to broadly maintain forest function, productivity, ecosystem services, and resilience and adaptation to future climate (Richardson, 2009) (Schwartz, 2012) (McLachlan, 2007). Below are three forms of assisted migration commonly used by practitioners, as defined by United States Forest Service (Handler, Pike, & St. Clair, 2024) and informed by Creating and Maintaining Resilient Forests in Vermont: Adapting Forests to Climate Change (Vermont Dept. of Forests, Parks and Recreation, 2015).
    a. **Assisted population migration** (APM) – moving seed sources or populations to new locations within the historical species range, but often at the northern latitudinal (or elevational) limits (Williams & Dumroese, 2013).
    b. **Assisted range expansion** (ARE) – moving seed sources or populations from their current range to suitable areas just beyond the historical species range, facilitating or mimicking natural dispersal. It aims to accelerate the dispersal process to areas where a species would naturally migrate if migration rates were able to keep pace with rate of climate change.
    c. **Assisted species migration** (ASM) – moving seed sources or populations to a location far outside the historical species range, beyond locations accessible by natural dispersal.
2. **Genotype** - In the context of planting, genotypes refer to the specific genetic makeup of individual trees or populations within a species. These genetic variations influence traits such as growth rate, resistance to diseases, tolerance to environmental conditions, and reproductive success. When selecting trees for planting, especially in reforestation or restoration efforts, choosing the appropriate genotypes is crucial to ensure that the trees can thrive in their specific environment, adapt to changing climate conditions, and maintain biodiversity.
3. **Local ecotype** - A subset of a plant species population of local or regional origin where the species population has genetically evolved and adapted over time based on environmental conditions. Local and regional origins of ecotypes can include VT, NH, NY, MA, ME, and adjacent Canadian provinces.
4. **Native plant species** - Indigenous species that occurred in this region prior to European colonization. Native plant species have co-evolved with other native wildlife and occur in a particular region, ecosystem, and habitat. (United State Forest Service, 2024).
5. **Non-native invasive species** - Species that have been introduced or dispersed from one region to another anywhere in the world, beyond their typical range, and whose presence in the environment results in economic, environmental, or human health detriments.
6. **Native range**[1] - The geographic area where the plant has historically thrived and is recognized to occur naturally.

[1] It is important to note that evidence from both western knowledge and traditional ecological knowledge support that indigenous peoples passively and actively moved masting fruit trees beyond their historic native range as means for sustenance (Abrams & Nowacki, 2008).

Planting Project Types

Planting projects on state lands are likely to fit into one of five major project type categories: research, erosion control and stabilization, landscaping, restoration, or adaptation. Some projects may fit into multiple categories and should be evaluated from the perspective of each relevant category. For example, although there are similarities between restoration and adaptation plantings, deciding which project type will depend on the goal of the project. Restoration plantings aim to bring back historical ecosystems, typically in degraded systems, while adaptation plantings look forward, selecting species and genotypes that are expected to survive and thrive in changing environmental conditions.

1. **Research.** This project type refers to planting projects that are being planned as part of a research effort on state lands and will require an application for a research license under the Uses of State Lands Policy.
2. **Erosion control and stabilization.** This includes projects implemented to prevent erosion, stabilize soils, and reduce stormwater runoff and may be used in conjunction with other project types to stabilize recently disturbed soil. This type of planting is usually implemented in log landings and along roadways, after new construction or infrastructure maintenance. Seed mixes topped with straw or other inert stabilizing materials are commonly used.
3. **Landscaping.** This project type occurs on managed landscapes that see heavy pedestrian use like parking areas, contact stations, park entrances, staff housing and other infrastructure, as well as landscaped areas adjacent to natural forest lands. The goals of the planting project may include aesthetic enjoyment, stormwater management, and habitat enhancement. This includes, but is not limited to, new small or large-scale planting and re-design efforts in Wildlife Management Areas, State Forests, State Parks, and associated facilities.
4. **Restoration**. This planting project type is implemented on state lands where the land has been altered significantly resulting in degraded or disturbed ecosystems. This project type covers forest and natural community restoration efforts; riparian restoration efforts on riverbanks, lake shores, wetlands, and floodplains; grassland bird habitat restoration; and species restoration[2,3]. Restoration projects can enhance ecological function, increase native biodiversity, create habitat or connectivity for native wildlife, increase flood resilience, and improve water quality.
5. **Adaptation[4].** Adaptation is the adjustment of systems in preparation or in response to ecological stressors such as climate change, pests, and pathogens. Adaptation includes assisted migration (AM) plantings which involve selecting and planting species or genotypes that are better suited to anticipated future environmental conditions, such as climate change, to enhance ecosystem resilience.

[2] Proposals to plant rare species are required to undergo review by the State Botanist and the Flora Advisory Group. These guidelines do not apply to conservation introduction, reintroduction, and population augmentation of rare and/or threatened plant species. In Vermont, current reintroduction and population augmentation efforts involve protected species including the federally threatened Jesup's milk vetch (*Astragalus robbinsii var. jesupii*) and the state-endangered wild lupine (*Lupinus perennis*).

[3] This includes the restoration of species populations that have been devastated by disease such as American elm (*Ulmus americana*) and American chestnut (*Castanea dentata*) but are still common on the landscape.

[4] The guidelines for assisted migration primarily focus on tree species and genotypes given the increased gene flow and higher genetic diversity of tree populations and lower risk of maladaptation.

Guidelines for Successful Planting Projects

This section of the guidance document includes two parts: general planting guidelines and project specific planting guidelines.

1. **General Planting Guidelines**. Includes 11 important considerations that apply broadly to all planting projects.
2. **Project Specific Planting Guidelines**. Provides specific guidance based on the project type and applies a decision framework to guide ANR staff when designing adaptation projects.

Accompanying resources to help with these guidelines are included in the Appendices and referenced in the text when applicable.

General Planting Guidelines

- Allow natural succession, regeneration, and re-vegetation to occur where practicable.
- Allow adequate time to consider and develop your planting project.
- Consider the current and future conditions and vulnerability of your planting site.
- Consider successional status, silvics, and stand dynamics.
- Consider indigenous and local knowledge.
- Choose species that are native and common to VT.
- Seek out local ecotype seeds and plants and consider genetics.
- Avoid introduction and spread of non-native invasive species, pests, and pathogens.
- Work with local or regional nurseries.
- Follow best practices for planting success.
- Plan for post-planting maintenance and monitoring.

Allow natural succession, regeneration, and re-vegetation to occur where practicable.

Where conditions allow, this should be the primary strategy for state land managers. Allowing natural regeneration is generally the most cost-effective option and lowest risk. Apply this within intact forest blocks and state-significant natural communities with sufficient regeneration where site resilience to climate impacts, pests, and pathogens is moderate to high and where invasive species regeneration is unlikely. For sites with low likelihood for erosion, this is also a viable and preferred option (i.e., flat areas in ROW and log landings). The focus of this guideline is for areas with sufficient regeneration of plant species at all levels - herbaceous, shrub, and tree.

Allow adequate time to consider and develop your planting project.

To guarantee lasting outcomes, dedicating time upfront for site evaluation, research, and securing all necessary plant or seed stock is critical. This initial investment ensures the project's success in the long run. Planning ahead ensures extra time for project review during the growing season and for finding appropriate seeds and planting stock. If local ecotypes are unavailable, extra time may be needed to source from regional nurseries (see Appendix F).

Consider the current and future conditions and vulnerability of your planting site.

Choosing plant species, genotypes, and stock types (e.g., seed, bare root, container, plugs) adapted to your site's current or future environment will result in a higher likelihood of success (Johnson, et al., 2010; Joshi, et al., 2001) and will help determine post planting maintenance (e.g., browse pressure may require caging plantings). If a plant is native to Vermont, that does not mean it is compatible with the planting site. For example, some plant species' ranges may be restricted (ex. swamp white oak along the Lake Champlain), whereas others are far-ranging (ex. sugar maple found statewide). Consider the following:

- What biophysical region is my site in?
- What are the soils, topography, hydrology, and existing vegetation at my site?
- Is there a natural community type[5] associated with the area I am planning to plant?
- What are the existing and potential future ecological conditions – are there disturbances and microclimates to account for?
- What is the USDA hardiness zone of my site?

To improve planting success, identify source populations that match either the current or predicted temperature and moisture regimes of the target site—depending on your project type (e.g., restoration or adaptation project) and target taxa (herbaceous or tree). Refer to Appendices B and C for additional resources on site conditions and ecoregions.

If your planting site has been altered, look at the native species makeup of a similar adjoining area that is more intact. Consider the current site conditions and future vulnerability of your planting site - forest type or species - to novel threats such as climate change, pests, and pathogens to determine how to maintain or enhance ecosystem function and diversity. When assessing the vulnerability of the site, consider what stressors the system is exposed to (e.g., changes in temperature and precipitation, flooding, pests, pathogens, etc.) and how sensitive that system is to those changes. In addition to the vulnerability, consider how the system may or may not have resilience to these potential impacts. Considering the vulnerability of the site helps make informed decisions with the management strategy and planting strategy being implemented. Resources on identifying current and future site conditions are listed in Appendix B and detailed considerations can be found in the Adaptation Project section on page 11.

Consider successional status, silvics, and stand dynamics.

For herbaceous communities, consider the successional status of the plant species and the target environment. For tree species, consider the silvics and stand dynamics when making management and planting decisions. For example, it is not advisable to plant all late successional trees in an open agricultural field as it disregards site conditions and normal ecological processes. If you are trying to establish a natural community type, *Wetland, Woodland, Wildland* (Thompson, Sorenson, & Zaino, 2019) provides a list of early successional species for the common types and Appendix D also provides

[5] In degraded areas, the natural community may not be obvious. If you are choosing to restore to the natural community type, work with the State Lands Ecologist to identify the potential community type. If you are restoring to a community type that is not a natural community (ex. grassland bird habitat), follow recommendations that meet your project goals.

information about which species are good for early successional planting. Further, utilizing *Silvics of North America* (Russell & Honkala, 1990) can help identify species silvics and stand dynamics to inform appropriate management guidance and species selection.

Consider indigenous and local knowledge.

Consider traditional ecological knowledge when making planting decisions. Projects ultimately benefit from indigenous and local knowledge and input, especially where partnerships are existing, where there are resources that are considered significant to the communities, where the communities will be impacted by the project outcomes, or the communities hold knowledge that benefit project outcomes (Höhl, et al., 2020; Robinson, et al., 2021; Santini & Miquelajauregui, 2022).

Choose species that are native and common to VT.

If a species selected for planting is rare, threatened, or endangered in VT, or not found in VT, additional review from the State Botanist is required. See Appendix H for information on Vermont's most up-to-date list of Rare and Uncommon Native Vascular Plants of Vermont (Vermont Fish & Wildlife Department, 2024).

Appendix D provides comprehensive lists of plant species for different uses and habitats in Vermont. A more detailed list of common species for a natural community type can be generated using *Wetland, Woodland, Wildland* (Thompson, Sorenson, & Zaino, 2019). It's very likely that some species will not be available for purchase and will need to be propagated in-house or in partnership with a local nursery if desired and depending on your project goals. In certain cases, on-site stock may be a good option for transplanting, particularly when the likelihood of success is high (e.g., transplanting common wood ferns, *Dryopteris* species).

To determine current and future species ranges of common native plants, recommended online resources include the Climate Change Tree Atlas and the Eastern Seed Zone Map which combines plant hardiness zones and ecoregions. These and additional resources can be found in Appendix B, C, and G. Finally, Appendix D (4), provides a list of tree species recommended for adaptation plantings.

Seek out local ecotype seeds and plants and consider genetics.

Ensuring genetic diversity and conserving local genotypes is important to the long-term viability of plant populations and their ability to adapt to current and changing ecological and climatic conditions (Johnson, et al., 2010). Examples include planting sugar maple trees that were grown from seed collected in an adjacent forest; purchasing red oak trees whose seeds were sourced and grown in NH within a similar climate and elevation as the planting site; or harvesting native willow cuttings from a stream site in Vermont and using them as stakes for a riparian restoration project at an adjacent streambank site.

In general, plants tend to grow better when the environmental conditions at the planting site closely resemble those of their original source. Studies suggest this is because species have evolved genetic adaptations to local environments, some more strongly than others, especially for herbaceous species. Since detailed information on specific species is limited, especially for specific taxa (e.g., herbaceous species), it is wise to take a cautious approach to improve the success of plantings in both the short and long term (United States Forest Service, 2024). The ecoregions in Appendix C serve as a framework for

selecting local ecotypic sources that are specifically adapted to the environmental conditions of a given planting site, thereby increasing the likelihood of successful establishment and growth.

For tree species, peer-reviewed literature and technical reports on genetic tests exist and have been incorporated into recommendations for seed transfer distances (Appendix D (4)). Many common garden experiments and field studies have been conducted to evaluate the relative performance of various provenances - the geographical location or environment where a plant population originated or was sourced - in different climatic regions. In some cases, provenances sampled from warmer climatic zones have demonstrated greater performance than local ones, although this is species dependent (Pedlar, McKenney, & Pengxin, 2021).

When planting sources of seeds, species, or genotypes that are not local ecotypes, risk of outbreeding depression - the mixing of two populations resulting in reduction in fitness of the offspring (Weeks, et al., 2011) - is highest for small populations with low levels of gene flow (Aitken & Whitlock, 2013). In herbaceous populations, the risk of outbreeding depression is generally higher due to greater genetic differentiation among populations, which arises from more limited gene flow and dispersal compared to tree species[6]. In contrast, tree populations, particularly those of wind-pollinated species, are generally at lower risk for outbreeding depression due to higher levels of gene flow over extensive geographical ranges[7] (Hamrick, Godt, & Sherman-Broyles, 1992). This increased gene flow reduces the degree of genetic differentiation among populations, allowing trees to maintain higher levels of genetic diversity within populations.

Nationwide it is recognized that commercial availability of local ecotypes can be a significant barrier to implementing planting projects (National Academies of Sciences, Engineering, and Medicine, 2023) (Tangren, Toth, & Siegel, 2022) (Clark, et al., 2023). Despite this challenge, obtaining local (e.g., Vermont) or regional (e.g., NY, MA, VT, NH, ME, and adjacent Canadian provinces) ecotype seed and plants is a priority to achieve our long-term goals for biodiversity, climate and non-native pest and pathogen adaptation, and healthy forests.

Avoid introduction and spread of non-native invasive species, pests, and pathogens.

To mitigate the introduction of non-native invasive species, the most effective approaches include promoting natural regeneration where possible, utilizing native local ecotypes, and sourcing plant materials from reputable, ecologically responsible suppliers. When developing planting plans and ordering or purchasing plant material, it is important to ask for complete scientific names of plants species (including subspecies if appropriate) to prevent introduction of non-native invasive species. While the following information focuses primarily on non-native invasive plants, species other than

[6] Herbaceous plants, particularly those in isolated or specialized habitats, often evolve strong local adaptations. When populations with distinct genetic backgrounds are crossed, the disruption of co-adapted gene complexes may lead to reduced fitness in the offspring, a hallmark of outbreeding depression. Furthermore, the shorter generation times typical of herbaceous species result in faster reproductive cycles, which can accelerate the manifestation of maladaptive traits introduced through genetic mixing, compounding the risk.

[7] 85-95% of the genetic variation in wind-pollinated, temperate tree species and 60-90% of genetic variation for coniferous species can be found within any single population due to high levels of gene flow, allowing for the mixing of genetic material over large distances. This increased gene flow reduces the degree of genetic differentiation between populations. Consequently, the introduction of non-local genotypes is less likely to disrupt locally adapted gene complexes (Hamrick, Godt, & Sherman-Broyles, 1992).

plants should be considered as well, especially when transplanting. These include organisms such as pests and pathogens like insects and fungi.

Species on the *Agency of Agriculture, Food & Markets' Noxious Weed List* and the *Exotic Plant Watch List* must be strictly avoided. The Vermont Invasives website (https://www.vtinvasives.org/) is a good resource for identifying invasive species. Finally, assessing invasive species presence and potential for regeneration at the planting site is also recommended, and ongoing control may be needed to ensure success. For example, equipment such as mowers or tracked vehicles can transport invasive plant species materials to a planting site resulting in a new introduction, or germination of dormant seeds may be encouraged through canopy openings and soil disturbance.

Work with local or regional nurseries.

Ensure that plants are sourced responsibly, choosing nursery-propagated or ethically salvaged options. Avoid wild-collected plants, as this practice can harm remaining wild plant communities and degrade natural ecosystems. A list of local and regional nurseries (northeast and north central United States) is included in Appendix F. This list will be expanded and updated as new resources become known.

Follow best practices for planting success.

There are several quality guides available for how to successfully plant perennials, shrubs, and trees. See Appendix E for a short list of resources.

Plan for post planting maintenance and monitoring.

Monitoring planting projects supports the success and maintenance of the planted stock. Monitoring can consist of checking mortality of plantings and replanting where needed, taking notes on successes and failures to share with others, and removal of planting cages or other protective equipment to prevent damage or mortality.

Guidelines for Planting Project Types

This section provides detailed information for each project type, specifying whether it requires project review and identifying the appropriate decision key to use for project planning. Refer to the project specific guidelines for your project type: research, erosion control and stabilization, landscaping, restoration, and adaptation. If your project falls into more than one project type, refer to both sets of guidelines for each type. All project types should adhere to their corresponding project-specific guidelines.

Research

1. Follow project specific guidelines of related projects. For example, if the research is for climate adaptation or restoration, follow the project specific guidelines for those project types.
2. This project type will require an application for a research license under the Uses of State Lands Policy.

Erosion Control & Stabilization

1. First consider if your site can revegetate naturally from the existing seedbank. If the site is mostly intact (ex. no existing invasive plant species, next to a minimally disturbed landscape) and is relatively flat and not adjacent to a water source, natural regeneration is preferred. In this case, only an inert mulching medium such as straw is recommended.
2. For disturbed sites where the goal is stabilization by establishing nonpermanent cover, mixtures of nonnative and native grasses plus legumes may be the most effective strategy. Both warm season and cool season mixes can be used on state lands.
    a. **Warm Season Cover Crop** (late May to mid-August) – grain oats (*Avena sativa*), red fescue (*Festuca rubra*), or annual ryegrass (*Lolium multiflorum*). All are non-native.
    b. **Cool Season Cover Crop** (late August to early May) – winter rye (*Secale cereale*) or autumn bentgrass *(Agrostis perennans*). The latter species is native.
    c. **Additional native species to add to create a mix** - Virginia wildrye (*Elymus virginicus*), little bluestem (*Schizachryrum scorparium*), deer tongue (*Dichanthelium clandestinum*), big bluestem (*Andropogon gerardii*), tufted lovegrass (*Eragrostis pectinacea*), showy tick-trefoil (*Desmodium canadense*) and tall lettuce (*Lactuca canadensis*). These native grasses and herbs provide valuable cover for wildlife and serve as host plants for many native insect species.
3. For disturbed sites where the objective is stabilization and the establishment of annual native vegetation cover for wildlife and pollinators, either a cool- or warm-season cover crop, supplemented with additional native species, may be utilized. Alternatively, any species included in the Erosion Control and Conservation Mixes[8] outlined in Appendix D is suitable.
4. When sourcing native seeds, inquire with the supplier about the geographical origin of the seeds. Preference should be given to seeds sourced from Vermont or adjacent regions to maintain ecological integrity and regional adaptation.
5. **The Project Review Process is NOT recommended when** using the seed mixes specified in Appendix D (2). Any additional non-native species not listed in Appendix D should be submitted for evaluation by the State Lands Ecologist.
6. **Click here or go to Appendix A (1) for the Erosion Control & Stabilization Decision Key.**

Landscaping

1. While staff may wish to utilize ornamental plants when landscaping, high-use areas present opportunities for public education as well as habitat potential, and native species are recommended as the first choice when planning plantings. Habitat enhancement as part of a landscaping project can include pollinator gardens that double as flower beds, and native shrubs with showy flowers and colorful berries that provide nutritious seasonal food sources. However, non-native ornamentals that do not exhibit invasive tendencies are unlikely to have a negative impact (e.g. pansies), particularly in areas where such cultivated species are already well established and do not pose a threat to natural systems. Care should be taken to avoid species likely to escape garden settings (e.g. Japanese tree lilac).
    a. Use the plant lists in Appendix D (1) as a guide for both native and non-native plantings.

[8] These seed mixes will be regularly updated through an iterative process informed by ongoing research and the increasing availability of native seed sources.

2. Extensive landscaping projects that abut natural intact forests, native plant communities, and water resources should focus on local ecotypes of native species in their landscape design.
    a. Appendix D (1) and D (3) provides a list of native plants to consider for landscape planting and Appendix F provides a list of nurseries for native plants.
3. **The Project Review Process is NOT recommended for** smaller landscaping projects or more complex projects in developed parks if the recommendations in #1 and #2 are followed.
4. **The Project Review Process is recommended for** complex planting projects abutting natural intact forests, native plant communities, and water resources (ex. Smuggler's Notch State Park scenic road parking improvements) where planting of local ecotypes of common native species cannot be achieved.
5. **Click here or go to Appendix A (2) for the Landscaping Decision Key.**

Restoration

1. In general, restoration planting projects take place on human-altered sites such as old agricultural fields, retired road or trail infrastructure, or modified streambanks, where the possibility of natural regeneration is unlikely, and the purpose is to achieve a naturally regenerative system that offers ecological values and benefits and requires only short-term maintenance. Additional restoration projects like pollinator gardens and grassland bird habitat, where long-term maintenance may be required, are also included.
2. Planting local ecotypes of common native species that are adapted to local site conditions is paramount in achieving biodiversity goals and planting success for restoration projects.
3. Utilize the best available science to employ implementation and increase planting success. *An introduction to using native plants in restoration projects* (Dorner, 2002), is a quality resource for developing restoration projects. This guide, used by the US Forest Service, provides details for guidance beyond the scope of this document (see Appendix E for additional resources).
4. Additionally, the appendices provide recommendations for plants by matrix community and site type along with other how to guides for native planting and local ecotype identification. Refer to Wetland, Woodland, Wildland (Thompson, Sorenson, & Zaino, 2019) to determine the likely natural community and lists of common species.
5. Follow the guidance in the adaptation project type is assisted migration is proposed.
6. **The Project Review Process is recommended for** restoration projects aimed at restoring natural systems such as forests and wetlands, or restoration where using common native local ecotypes may not achievable (ex. grassland bird habitat).
7. **Click here or go to Appendix A (3) for the Restoration Planting Decision Key.**

Adaptation

Adaptation refers to the process of adjusting systems to prepare for or respond to novel stressors (e.g., climate change, pests, and pathogens) and can incorporate assisted migration plantings as an adaptation strategy. Assisted migration involves strategically selecting and planting species or genotypes that are expected to be better suited to future environmental conditions, thereby improving the climate resilience of ecosystems. Of note, these guidelines for assisted migration primarily focus on tree species and genotypes given the increased gene flow and higher genetic diversity of tree populations[9]. Trees

[9] Refer to general guidelines for greater detail.

typically have longer generation times and slower rates of evolutionary change, which buffer against the rapid emergence of maladaptive traits. If you are considering assisted migration for herbaceous communities, please contact the State Botanist to minimize risk of outbreeding depression[10].

The intentional movement of tree species or genotypes can introduce or increase the frequency of pre-adapted genotypes within a population (Aitken & Whitlock, 2013), making it essential for assisted migration strategies to focus on identifying source populations that match the temperature and moisture regimes of the target site. Ensuring that species and populations are adapted to local conditions helps maintain or improve forest resilience, safeguarding against climate change impacts like drought and insect or pathogen attacks (Thompson, Mackey, McNulty, & Mosseler, 2009). Preserving within-population variation and maintaining a broad genetic base is crucial, as the aim is to augment, not replace, existing seed zones. Further, composite provenancing—drawing from multiple source populations—can increase genetic diversity (Aitken & Bemmels, 2015).

1. These planting guidelines are meant to accompany climate adaptive forest management strategies in Appendix G and encompass only plantings that can be categorized as either assisted population migration (APM) or assisted range expansion (ARE). The main form of assisted migration often used in forestry applications is assisted population migration (APM), which may constitute a less risky approach (e.g., maladaptation and invasion), particularly for trees (Mueller & Hellmann, 2008) (Twardek, 2023) (Pedlar J. H., et al., 2012). This can include enhancing the representation of a species already present at the site in low abundance but expected to increase or using more southern genotypes of a species. It is advisable to proceed with caution when implementing forms of assisted migration, considering the uncertainties inherent in climate change, limited nursery stock and capacity (Clark, et al., 2023), as well as insufficient understanding of how assisted migration affects populations and communities at large (Twardek, 2023).
2. Tree planting efforts must be based on scientific research to ensure the "right tree is planted in the right location." Well-established guidance exists for seed zone selection for tree planting projects (e.g., (Pike, et al., 2020) Appendix C - Eastern Seed Zone Map) and peer-reviewed literature and technical reports exist on provenance tests for many species. Summary tables for six species of interest are presented and include information on genetics, insect and disease susceptibility, and maximum transfer distance adapted from The Forest Service National Center for Reforestation, Nurseries, and Genetic Resources (RNGR) found in Appendix D (4). In general, most tree species reviewed have high genetic diversity and therefore, presumably high capacity for adaptation to new conditions. Seed sources from short distances south of the planting site do as well or better than local material, although this is species dependent (Pedlar, McKenney, & Lu, 2021). *At any point during the project development, the Climate Forester can be consulted for additional guidance.*
3. On Agency lands, of the assisted migration types (e.g., APM, ARE, and ASM) **there are currently no scenarios where it is appropriate to utilize ASM**, for moving seed sources or populations to a location far outside the historical species range.
4. **The Project Review Process is recommended for** all adaptation projects.
5. **Click here or go to Appendix A (4) for the Adaptation Planting Decision Key.**

[10] Outbreeding depression refers to the mixing of two populations resulting in the reduction in fitness, or reproductive success, of the offspring and is highest for small populations with low levels of gene flow.

Project Review Process

As described in the Project Specific Guidelines, the project review process is recommended for certain planting projects and is conducted by the District Stewardship Team (DST). These guidelines aim to standardize and clarify the project review process, ensuring greater success in planting projects while promoting the preservation of ecological function and biodiversity at both the project site and landscape scale. The outcome of the review process should be a recommendation from the District Stewardship Team. This process applies to some landscaping and research projects, restoration projects, and assisted migration projects where planting is being implemented.

Use the Guidelines for Planting Project Types or the Project Type Decision Keys in Appendix A to determine if your project should undergo the Project Review Process.

Project Review Steps

1. ***Specified planting projects, as described in the Project Specific Guidelines or Project Type Decision Keys, should be entered into Land Manager, added to the Annual Stewardship Plan (ASP), and reviewed by the District Stewardship Team.*** When entering the project into Land Manager, be sure to specify the planting project type(s).
2. ***Minimum information should be submitted for a sufficient review.*** The following information should be entered into Land Manager and provided to the District Stewardship Team for review:
    a. Description of planting project with clearly articulated management goals, objectives, and how the site will be monitored to evaluate success.
    b. A map showing the proposed project area and the size of the planting area or a planting design (if available).
    c. List of species names with local ecotype information if available (e.g., source area).
    d. Description of the type of planting plan (ex. bare root, potted, seeds).
    e. Anticipated timeline for the project.
3. ***Additional review or information may be requested.*** Based on the Planting Project Guidelines, if the project is identified as needing additional review, the DST may seek input from other ANR staff, such as the State Botanist, and/or State Climate Forester, to determine what additional information or support is needed to review the project to provide a recommendation.
    a. If additional information is needed for review, the project timeline may need to be extended outside of the ASP timeline.
4. ***A final decision should be made.*** The DST will conduct a thorough evaluation and make a final determination on whether to advance the project, following the standard review process outlined in the Interagency Memorandum of Understanding (MOU).

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Appendices

Appendix A. Project Type Decision Keys

Four out of the five project types have associated decision keys to help staff make decisions about how to apply the planting guidelines. Research is the only project type that does not have a decision key. For research, refer to the related project type decision key.

1a. Project Type: Erosion Control and Stabilization (EPS)

1. **Determine your site conditions.**
   - **a) Is your planting site at least 25-ft from a water resource (ex. wetland, stream, river, lake or pond?**
     - i) **Yes** → Proceed to 1b.
     - ii) **No** → Go to 2.
   - **b) Determine the erosion potential and regenerative capacity of your site. Is site relatively flat and unlikely to erode during a runoff event if not seeded and mulched, and is your site adjacent to natural conditions with no invasive species present?**
     - i) **Yes** → Proceed to 1c.
     - ii) **No** → Proceed to 2.
   - **c) Consider mulching only and allow native regeneration through the existing seedbank.** This is most likely to be successful during the warm season (late May to mid-August).
2. **Determine the goal of your planting.**
   - **a) Is the goal of the planting for both EPS and establishment of native vegetation cover for wildlife and pollinator value?**
     - i) **Yes** → Proceed to steps 3 & 4.
     - ii) **No** → Proceed to step 2b.
   - **b) Is the goal of the planting primarily for erosion prevention and sediment control (EPS)?**
     - i) **Yes** → Proceed to 3 only.
     - ii) **No** → **Refer to other project types that meet your planting goals**.
3. **Determine EPS plant cover type.**
   - **a) Are you planting between in late May to mid-August?**
     - i) **Yes** → Proceed to 3b.
     - ii) **No** → Proceed to 3c.
   - **b)** Plant a warm season cover crop species (late May to mid-August) of grain oats (*Avena sativa*), red fescue (*Festuca rubra*), or annual ryegrass (*Lolium multiflorum*). All are non-native. Apply to site with straw mulch or other inert mulch. **Proceed to Step 5.**
   - **c)** Plant a cool season cover crop species (late August to mid-May) – winter rye (*Secale cereale*) or autumn bentgrass (*Agrostis perennans*). The latter species is native. Apply to site with straw mulch or other inert mulch. **Proceed to Step 5.**
4. **In addition to the EPS cover crop, choose from a list of native species to plant as a wildlife and pollinator mix. See Appendix D for more plant species.**

a) Virginia wildrye (*Elymus virginicus*), little bluestem (*Schizachryrum scorparium*), deer tongue (*Dichanthelium clandestinum*), big bluestem (*Andropogon gerardii*), tufted lovegrass (*Eragrostis pectinacea*), showy tick-trefoil (*Desmodium canadense*), and tall lettuce (*Lactuca canadensis*). **Proceed to Step 5.**

5. **Are you using ONLY native seeds or seeds from the species listed above or in Appendix D?**
   - **a) Yes → This planting does NOT need project review.**
   - **b) No** → Proceed to 6.
6. **Is the project an emergency that doesn't allow for adequate time to source preferred seed mixes?**
   - **a) Yes → This planting does NOT need project review**.
   - **b) No → Contact the State Lands Ecologist to ensure that ecological harm is unlikely**.

1b. Project type: Landscaping

1. **Determine the scope of the project.**
   - **a) Is the project self-contained (ex. container garden, flower boxes, etc)?**
     - i) **Yes** → Proceed to 1b.
     - ii) **No** → Proceed to 2.
   - **b) This planting does NOT need project review.** Go to Appendix D (1) for a list of species for ornamental planting. Additionally, the Vermont Fish and Wildlife Department website has a list of perennial plants for birds and pollinators that describes blooming periods and plant heights (https://vtfishandwildlife.com/learn-more/vermont-plants/pollinator-friendly-plants). These high-use areas present opportunities for public education as well as habitat potential, and native species are recommended as the first choice when planning plantings.
2. **Is the project a landscape planting** (ex. flower beds, edge landscaping, landscaped island, etc.) **in a developed area, not directly adjacent to water resources** (ex. shores of streams, rivers, lakes, ponds, wetlands) **or an intact forest system** (ex. a forest that primarily formed under natural conditions, is not maintained, has a natural understory, and is not a plantation)**?**
   - i) **Yes** → Proceed to 2a.
   - ii) **No** → Proceed to 3.
   - **a) This planting does NOT need project review.** Go to Appendix D (1) for a list of species for landscape projects in developed areas. Additionally, the Vermont Fish and Wildlife Department website has a list of perennial plants for birds and pollinators that describes blooming periods and plant heights (https://vtfishandwildlife.com/learn-more/vermont-plants/pollinator-friendly-plants).

     These high-use areas present opportunities for public education as well as habitat potential, and native species are recommended as the first choice when planning plantings. Habitat enhancement as part of a landscaping project can include pollinator gardens that also double as flower beds or the planting of native berry shrubs to provide spring flowers and a fall food source for birds. However, non-native ornamentals that do not exhibit invasive tendencies are unlikely to have a negative impact (e.g. pansies), particularly in areas where such cultivated

species are already well established and do not pose a threat to natural systems. Care should be taken to avoid species likely to escape garden settings (e.g. Japanese tree lilac).

3. **Is the project a simple landscape planting that includes plantings directly adjacent to water resources** (ex. shores of streams, rivers, lakes, ponds, wetlands) **or an intact forest system** (ex. a forest that primarily formed under natural conditions, is not maintained, has a natural understory, and is not a plantation)**?**

    i) **Yes** → Proceed to 3a.
    ii) **No** → Proceed to 4.

    a) Will the plantings be common native local ecotypes?

    i) **Yes → This planting does NOT need project review.** Follow the General Planting Guidelines and see Appendix D for native plant lists to match your site needs. Additionally, the Vermont Fish and Wildlife Department website has a list of perennial plants for birds and pollinators that describes blooming periods and plant heights (https://vtfishandwildlife.com/learn-more/vermont-plants/pollinator-friendly-plants).
    ii) **No → Contact the State Lands Ecologist to ensure that ecological harm is unlikely.**

4. **Is the project a complex landscape planting** (ex. part of a larger engineering design or includes landscape design specifications) **that includes plantings directly adjacent to water resources** (ex. shores of streams, rivers, lakes, ponds, wetlands) **or an intact forest system** (ex. a forest that primarily formed under natural conditions, is not maintained, has a natural understory, and is not a plantation)?
    i) **Yes** → Proceed to 4a.
    ii) **No** → We have not anticipated your project type. **Check in with the State Lands Ecologist for further guidance or refer to other project types.**

    a) Will the plantings be common native local ecotypes?

    i) **Yes → This planting does NOT need project review.** Follow the General Planting Guidelines and see Appendix D for native plant lists to match your site needs.
    ii) **No → Project review is recommended for this planting.** Follow the General Planting Guidelines and Project Review Process.

1c. Project type: Restoration

This decision key is built on the assumption that restoration planting projects are taking place on human-altered sites such as old agricultural fields, retired road or trail infrastructure, or modified streambanks, where the possibility of natural regeneration is unlikely, and the purpose is to achieve a naturally regenerative system that offers ecological values and benefits and requires only short-term maintenance.

1. **Determine the goal of your restoration project.**

    a) To restore an open site to a forest?

    i) **Yes** → Proceed to 2.
    ii) **No** → Proceed to 1b.

    b) To restore a floodplain or wetland?

i) **Yes** → Proceed to 3.
ii) **No** → Proceed to 1c.

c) To plant a pollinator or native plant garden?

i) **Yes** → Proceed to 4.
ii) **No** → Proceed to 1d.

d) To create an open field environment for wildlife value?

i) **Yes** → Proceed to 4.
ii) **No** → Proceed to 1e.

e) To restore a road or trail site?

i) **Yes** → Proceed to 5.
ii) **No** → Proceed to 1f.

f) We do not have further recommendations for this type of restoration planting. Follow the General Planting Guidelines and Project Review Process.

2. Follow the General Planting Guidelines and Project Review Process. Information and guidance on plants to consider for natural community forest matrix types and open sites is found in Appendix D (3). Appendix E includes information on site preparation and techniques for planting trees and shrubs.

Depending on the community type you are trying to restore, you may want to consider more extensive site preparation techniques such as exposing loose mineral soils to allow for regeneration of certain species. You may also want to consider if natural regeneration is possible and what can be supplemented by planting.

Appendix F provides a list of local nurseries for planting stock. In some cases, a native conservation mix can create a natural cover for native species to regenerate (see Appendix D (2) for conservation mix suggestions). Thick thatch or cover of other non-native species can be a challenge for this type of restoration.

3. Follow the General Planting Guidelines and Project Review Process. Information and guidance on plants to consider for floodplain and wetland sites is found in Appendix D (3). Appendix E provides information on site preparation and techniques for planting trees and shrubs and includes guides specific to riparian planting projects.

If the site is a wetland, the minimal information required for the Project Review Process should be submitted as a restoration plan to the Vermont Wetlands Program. The Wetlands Program Restore webpage also provides resources on wetland restoration.

Depending on the community type you are trying to restore, you may want to consider more extensive site preparation techniques such as pre-treatment of invasive or nuisance species that prevent regeneration and growth of native plants. Chemical treatment in wetlands also requires review by the Vermont Wetlands Program.

You may also want to consider if natural regeneration is possible and what can be supplemented by planting. Appendix F provides a list of local nurseries for planting stock. In some cases, a native conservation mix can create a natural cover for native species to regenerate (see Appendix D (2) for conservation mix suggestions). Thick thatch or cover of other non-native species can be a challenge for this type of restoration.

4. **Does the project propose plantings directly adjacent to water resources** (ex. shores of streams, rivers, lakes, ponds, wetlands) **or an intact forest system** (ex. a forest that primarily formed under natural conditions, is not maintained, has a natural understory, and is not a plantation)**?**

    i) **Yes** → Proceed to 4a.
    ii) **No** → Proceed to 4b.

    a) Will the plantings be common native local ecotypes (exceptions for non-native species included in Appendix D (2))?

    i) **Yes** → **This planting does NOT need project review.** Follow the General Planting Guidelines and see Appendix D for native plant lists to match your site needs. The erosion control and conservation mixes in Appendix D (2) include many native forbs and shrubs for wildlife, pollinator, and education purposes. Additionally, the Vermont Fish and Wildlife Department website has a list of perennial plants for birds and pollinators that describes blooming periods and plant heights (https://vtfishandwildlife.com/learn-more/vermont-plants/pollinator-friendly-plants).

    ii) **No** → **Project review is recommended for this planting.** Follow the General Planting Guidelines and Project Review Process. Native species are recommended as the first choice when planning plantings. The erosion control and conservation mixes in Appendix D (2) include many native forbs and shrubs for wildlife, pollinator, and education purposes. Additionally, the Vermont Fish and Wildlife Department website has a list of perennial plants for birds and pollinators that describes blooming periods and plant heights (https://vtfishandwildlife.com/learn-more/vermont-plants/pollinator-friendly-plants).

    b) This planting does NOT need project review. Native species are recommended as the first choice when planning plantings**.** Follow the General Planting Guidelines and see Appendix D for native plant lists to match your site needs. The erosion control and conservation mixes in Appendix D (2) include many native forbs and shrubs for wildlife, pollinator, and education purposes. Additionally, the Vermont Fish and Wildlife Department website has a list of perennial plants for birds and pollinators that describes blooming periods and plant heights (https://vtfishandwildlife.com/learn-more/vermont-plants/pollinator-friendly-plants).

5. **Is the project proposing to use an erosion control or conservation mix for wildlife?**

    i) **Yes** → Go to the decision key for Erosion Control & Stabilization.
    ii) **No** → Proceed to 5a.

    a) Will you be using ONLY local transplanting and natural regeneration techniques?

    i) **Yes** → **This planting does NOT need project review.** Follow the General Planting Guidelines where applicable.

    ii) **No** → Proceed to 5b.

    b) Will the plantings be common native local ecotypes?

    i) **Yes** → **This planting does NOT need project review.** Follow the General Planting Guidelines and see Appendix D for native plant lists to match your site needs.

    ii) **No** → **Project review is recommended for this planting.** Follow the General Planting Guidelines and Project Review Process.

1d. Project type: Adaptation Planting*

The Project Review Process is recommended for all adaptation planting projects.

This decision key is intended for the use of tree plantings only. If you are interested in assisted migration of shrub and herbaceous communities, please consult the State Botanist. Before considering tree assisted migration options, first determine if other silvicultural or climate change adaptation strategies (Appendix G) can achieve your stated goals and anticipated outcomes. If assisted migration is identified as a needed strategy, Assisted Population Migration (APM) has been recognized as a low-risk adaptation strategy. Assisted Range Expansion (ARE) should be approached with caution and would only be considered through research with a formal monitoring process.

1. **Determine the condition of your site (e.g., intact forest, fragmented forest, degraded system).**
   - **a) Is your site a fragmented or a degraded system?**
     - i) **No** → Proceed to 1b
     - ii) **Yes** → Planting is a recommended strategy for these sites. Proceed to step 2.
   - **b) Is your site within an intact forest block?**
     - i) **No** → refer to 1a.
     - ii) **Yes** → For planting within intact forest blocks, sites need to have high vulnerability to climate change or other stand altering disturbances. Further, these sites should have a lack of regeneration of desired species. It is important to note that planting should be motivated by the goal to augment, not replace, existing species or genotypes through adding functional redundancy and diversity[11]. Proceed to step 2.
2. **Is the target community classified as S1 or S2 (rare or imperiled)?**
   - **a) No** → Proceed to step 3.
   - **b) Yes** → This is only recommended for assisted migration under special circumstances (e.g., Pine Oak Heath Sandplain Forest). Please proceed to step 5.
3. **Is the target community classified as S3?**
   - **a) No** → Proceed to step 4.
   - **b) Yes**→ This may be appropriate for assisted population migration (APM). Proceed to step 5.
4. **Is the target community classified as S4 or S5?**
   - **a) No** → If you are unable to determine your community classification, contact the State Lands Ecologist.
   - **b) Yes** → This may be eligible for assisted population migration (proceed to step 5) or assisted range expansion[12] (proceed to step 6).

[11] **Functional Redundancy** refers to the presence of multiple species within an ecosystem that perform similar roles or functions. If one species declines or goes extinct, others can continue performing that function, maintaining ecosystem stability; **functional diversity** refers to the range of different functions or ecological roles that species play within an ecosystem.

[12] Assisted Range Expansion (ARE) should be approached with caution. ARE would only be considered through a research lens with formalized monitoring.

5. **Assisted population migration (APM):** Determine the goals of your planting type.

   a) **If your goal is to increase density or diversity of a certain native species, appropriate to the natural community, and adapted to *current, local site conditions*, utilize locally adapted genotypes either collected from the site or from local nursery stock (eastern seed zone map). Use the following steps and then proceed to Step 7.**

      i) Utilize WWW to determine species suitable for the site.

      ii) Utilize the eastern seed zone map—which incorporates both plant hardiness zones and ecoregions (Pike, et al., 2020)—to identify suitable seed zones and work with local nurseries to source stock. See Appendix F for Northeastern Nurseries.

      iii) Utilize Silvics of North America (Burns & Honkala, 1990) (Appendix B) to determine appropriate management strategies to accompany planting to ensure site conditions are suitable for species being planted. **Proceed to Step 7**

   b) **If your goal is to increase density or diversity of a certain native species, appropriate to the natural community, and adapted to *future conditi*ons, select genotypes from the region reflecting future conditions of your site. Use the following steps and then proceed to Step 7. Proceed to Step 7 to determine seed transfer distance for selected species.**

      i) Utilize both WWW and the Climate Change Tree Atlas to identify species suitable for your site. Recommended species, including information on genetics, insects and diseases, and seed transfer distance is included in Appendix E.

      ii) Utilize the eastern seed zone map—which incorporates plant hardiness zones and ecoregions (Pike, et al., 2020)—to identify suitable seed zones and work with available nurseries to source stock. See Appendix F for Northeastern Nurseries.

      iii) Utilize Silvics of North America (Burns & Honkala, 1990) (Appendix B) to determine appropriate management strategies to accompany planting to ensure site conditions are suitable for species being planted. **Proceed to Step 7 to determine seed transfer distance for selected species.**

   c) **If your goal is to include both local and adapted seed sources use both local nursery stock and regional nurseries that have appropriate seed sources. Proceed to step 7.**

      i) Utilize the eastern seed zone map—which incorporates plant hardiness zones and ecoregions (Pike, et al., 2020)—to identify suitable seed zones and work with available nurseries to source stock. See Appendix F for Northeastern Nurseries.

      ii) Utilize Silvics of North America (Burns & Honkala, 1990) (Appendix B) to determine appropriate management strategies to accompany planting to ensure site conditions are suitable for species being planted. **Proceed to Step 7 to determine seed transfer distance for selected species.**

6. **Assisted Range Expansion (ARE):** This type of planting should be approached with caution and requires thorough review and thoughtful implementation given the higher risk of maladaptation. Further, this type of planting should only occur in degraded or fragmented landscapes and requires a formalized monitoring protocol.

7. **Determining Seed Transfer Distances**—the geographic range or distance over which seeds can be moved from their source location and still perform well in a new environment. **Has the species been tested for genetic adaptability in different climates (common garden studies or field tests)? Refer to Appendix D, section D4, for guidance on six species selected as potential plantings which includes peer-reviewed guidance on transfer distance and genetic information** [13]

   a) **Yes** → Follow tested guidelines for latitudinal transfers. Please refer to the Appendix D, section 4d, for species-specific recommendations, including information on geneflow, genetic diversity, insects and disease, and maximum transfer distance for the following species: Eastern white pine, Northern red oak, yellow birch, sugar maple, red spruce, and black cherry**. Monitoring is required for assisted migration plantings. Proceed to step 8**

   b) **No** → For general guidance, use a conservative transfer distance by moving seeds northward by 2-3 degrees of latitude (approximately 200-300 km) to match future conditions for your specific site. **Monitoring is required for assisted migration plantings. Proceed to step 8.**

8. **Monitoring: all assisted migration plantings, regardless of the number planted, should be monitored using the following protocol during year one, three, and five following the planting.**

   a) **Data Collection**

      i) The greater of 1% or ten trees of each seed source will be tracked for survivorship regardless of how many trees are planted in years one and three after planting.

      ii) A subset of assisted migration plots planted in year one will be revisited in year five to assess condition and competition.

      iii) Stands performing adequately will no longer be monitored. Stands with poor condition and/or high competition that may require release or timber stand improvement (TSI) activities will be revisited and evaluated following release or other TSI activities to determine if additional monitoring is necessary at year ten.

      iv) An additional subset of assisted migration stands may be revisited once the tree species have reached the age of first cone/seed production to monitor productivity and viability.

      v) Climate data: Climate conditions from the nearest weather station (usually District level) should also be monitored. This data will be collected by the Climate Forester.

   b) **Analysis**: The Climate Forester will summarize these data for biennial monitoring reports. If survival and/or condition of the assisted migration stock is substantially lower than expected, potential adjustments to implementation of assisted migration will be made.

[13] For species with information from common garden experiments, transfer distances may range from 2-5 degrees of latitude or adjacent seed zones (approximately 200-500 km).

Appendix B. Resources for Determining Site Conditions & Species Range

Online tools for exploring site conditions remotely are available from state, federal, and non-profit organizations. A few of these tools are listed below. One comprehensive tool that can be used for this purpose is the ANR Natural Resources Atlas: https://anrmaps.vermont.gov/websites/anra5/.

1. **Find your biophysical region**.
    a. Biophysical Regions of Vermont: https://vtfishandwildlife.com/sites/fishandwildlife/files/documents/Learn%20More/LandownersGuide/2.BiophysicalRegions.pdf.
2. **Determine site conditions** - soils, topography, hydrology, and existing vegetation at your site.
    a. Web Soil Survey: https://websoilsurvey.nrcs.usda.gov/app/.
    b. Vermont Center for Geographic Information Interactive Map Viewer: https://maps.vermont.gov/vcgi/html5viewer/?viewer=vtmapviewer.
    c. There are numerous plant keys, identification guides, and online resources for plant identification and required site conditions for plant species. You can also consult with a botanist or ecologist for plant identification purposes. Two quality resources for plant identification are GoBotany which includes look-alikes and the Flora of North America online key, and the iNaturalist app which uses crowd sourcing for identification confirmation. The Silvics of North America is a seminal guide for tree species providing information on species specific site conditions, germination requirements, and more.
        i. GoBotany: https://gobotany.nativeplanttrust.org/
        ii. iNaturalist: https://www.inaturalist.org/
        iii. Wildflower Search: https://wildflowersearch.org/
        iv. Silvics of North America
            1. Silvics of North America: Volume 1. Conifers: https://research.fs.usda.gov/treesearch/1547
            2. Silvics of North America: Volume 2. Hardwoods: https://research.fs.usda.gov/treesearch/1548
3. **Identify your natural community type.** Categorizing vegetation into natural communities helps ecologists, land managers, and conservationists understand and manage ecosystems more effectively. Knowing your natural community can help to guide restoration projects to maintain or re-establish native ecosystems. Identify the natural community type associated with the area you are planning to plant.
    a. VT Significant Natural Communities: https://geodata.vermont.gov/datasets/837e09c281204f15a54478f7e469a955/explore.
4. **Identify your hardiness zone.** A hardiness zone map provides information about the climate suitability of different plant species based on the minimum winter temperatures in specific geographic areas. The map divides regions into zones, usually based on average annual extreme minimum temperatures, allowing users to select plants that are more likely to thrive in their local environment.
    a. Hardiness Zone Maps: https://planthardiness.ars.usda.gov/
5. **Identify the species that occur within the area you are planting**. Species range maps have been developed for most common herbaceous, shrub, and tree species. More information on seed zones and ranges for local ecotypes is found in Appendix C.

a. Range Map Resources
    1. Go Botany: https://gobotany.nativeplanttrust.org/
    2. USDA Plants Database: https://plants.usda.gov/home
    3. The Biota of North America Program: http://www.bonap.org/
    4. Individual Tree Species Parameter Maps: https://www.arcgis.com/home/item.html?id=4ebf103ddeeb4766a72e58cb786d3ee2.
    5. Eastern Seed Zone Map: https://www.arcgis.com/apps/webappviewer/index.html?id=7f1fbeefbc074301af487e817cbca927
    6. Wildflower Search: https://wildflowersearch.org/

Appendix C. Resources for Planting Success and Species Conservation

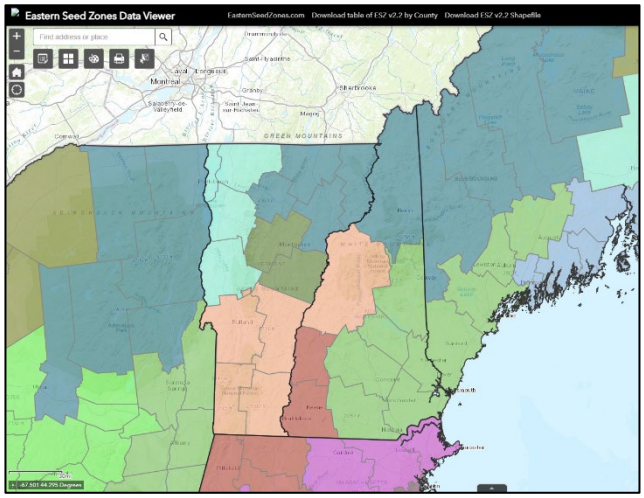
Identifying a local ecotype plant or seed is aided by an understanding of a species seed zone, historical and predicted range, and natural community association. Sources describing seed zones, plant species ranges, and natural communities are continuously being developed and updated as species ranges shift and new information is discovered and analyzed. These tools help practitioners to have the most success in their native planting efforts to benefit pollinators, wildlife, forest health, and natural community and ecological function, while also protecting local genetics and gene flow.

A **seed zone** is a geographically defined area within which plant seeds can be collected and used for reforestation or restoration projects to ensure that the resulting plants are well-adapted to the local environmental conditions. The concept of seed zones is based on the idea that local populations of plants have evolved specific adaptations to their local climates, soils, and other ecological factors. Using seeds from within the same zone helps maintain genetic diversity and enhances the survival and growth of planted trees or plants (Gaston, 2003) (Ricklefs, 2000).

Species range refers to the geographical area where a particular plant species can be found. This range includes all the places where the species naturally occurs and thrives. The range can be influenced by various factors, including climate, soil type, availability of water, and interactions with other organisms. It can be continuous or fragmented and may change over time due to environmental changes or human activities (Johnson, Sorensen, St. Clair, & Cronn, 2004).

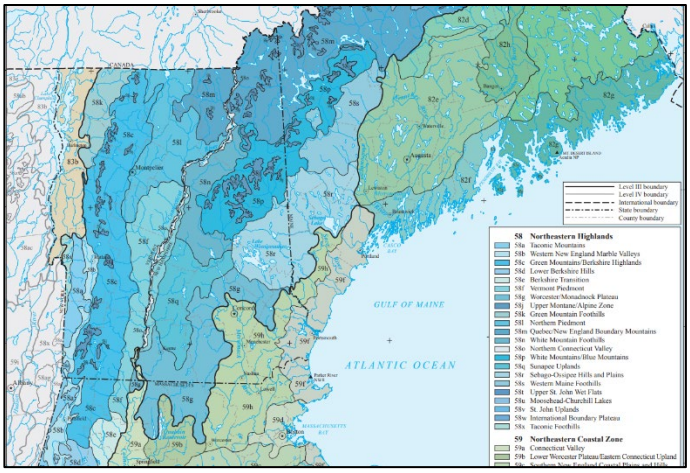
A **natural community** is an interacting assemblage of organisms, their physical environment, and the natural processes that affect them (Thompson, Sorenson, & Zaino, 2019).

Four primary sources are recommended in this document to determine the best suited local ecotype. There are numerous other sources online and published in books that can also provide information on the range and preferred environmental conditions of plant species that can be used in conjunction.



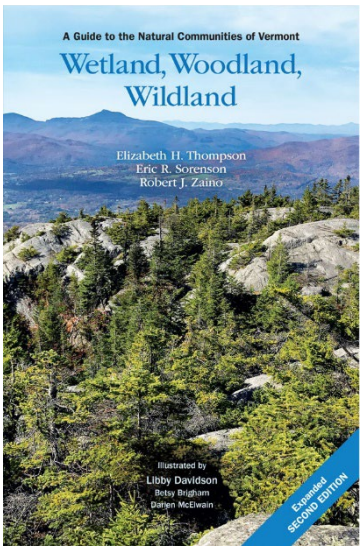
The Eastern Seed Zone Map: Recommended for both restoration and adaptation plantings. Developed by the USDA Forest Service and collaborators to determine seed zones for the eastern US, a region spanning 24 states, from Maine to Minnesota, Texas to Florida. The effort is intended to develop seed zones for trees and smaller subzones for non-woody plants. These maps are granular enough for selecting appropriate seed sources for planting projects. Common garden studies are still considered the best method for determining how far seeds can be moved from their original collection zones. For species that haven't been tested in the field, a prudent general guideline is to restrict seed movement either within the same collection zone or between neighboring zones. Source: https://www.arcgis.com/apps/webappviewer/index.html?id=7f1fbeefbc074301af487e817cbca927

Level III and IV Ecoregions of New England Map: Developed by USEPA, USDA Forest Service, USDA NRCS, and New England state environment and natural resource agencies, as well as with other collaborators and contributors. The map is tool for planning and executing planting projects, as it provides detailed information on ecological regions based on landforms, climate, soil types, and vegetation. By using this map, planners can identify specific ecoregions that offer insights into the native plant species best suited to local environmental conditions, which supports the selection of appropriate plants for restoration, conservation, or landscaping project.



Sources: https://gaftp.epa.gov/EPADataCommons/ORD/Ecoregions/reg1/new_eng_map.pdf (static map), https://www.arcgis.com/home/item.html?id=a550ce1ee2614125b35e522d7ab69770 (interactive map)

Native Plant Trust: Go Botany: Go Botany is an educational website developed by the Native Plant Trust, aimed at promoting the understanding and conservation of native plants in New England. It is a valuable resource for planting projects, especially in New England, offering a comprehensive, user-friendly plant identification tool and an extensive database of native and introduced plant species. For ecological restoration, GoBotany provides detailed information on species' habitat requirements, growth habits, and ecological preferences. This makes it easier for managers to choose appropriate plants that will thrive in specific environments, contributing to more successful and sustainable projects. The site also includes guides on plant characteristics, flowering times, and environmental tolerances, which can be crucial for selecting species suited to particular climates, soil types, or moisture levels. Source: https://gobotany.nativeplanttrust.org/



A Guide to Natural Communities of Vermont: Wetland, Woodland, Wildland: A comprehensive and richly detailed guidebook that explores the diverse natural communities found throughout Vermont. Authored by Elizabeth H. Thompson, Eric R. Sorenson, and Robert J. Zaino, the book serves as an essential resource for understanding the intricate ecosystems that characterize the state's landscapes. The book provides in-depth descriptions of the state's natural communities, including their characteristic plant species, soils, moisture levels, and ecological processes. This guide helps land managers understand the specific conditions of different habitats, ensuring that plant selections align with the local environment and are well-suited to thrive in their designated areas.

By offering detailed information on Vermont's forests, wetlands, and wildlands, the guide supports efforts to restore or enhance native ecosystems, encouraging the use of species that are ecologically appropriate and promoting biodiversity. Additionally, it aids in identifying the right plant species for different community types, whether the project involves reforestation, wetland restoration, or wildlife habitat enhancement. This comprehensive understanding helps create planting projects that are ecologically sustainable and more resilient to environmental changes. Plant lists by matrix community type are found in Appendix D, Section D3.

Appendix D. Plant Lists for Landscaping, Erosion Control and Stabilization, Restoration, and Adaptation Planting Projects

The following section is intended to provide ANR staff with resources to construct resilient and affordable plantings that more accurately reflect the diversity and composition of Vermont's natural communities. To this end, we have constructed planting lists that represent the general ecology of Vermont's foremost matrix communities: Northern Hardwood Forest Formation, Spruce-Fir-Northern Hardwood Forest Formation, Oak-Pine-Northern Hardwood Forest Formation, and Vermont's Floodplain Forests. Considering that the successional status of a site has substantial bearing on the success of a given species, the successional role of each species in our Upland Forest Community Planting Lists has been denoted to direct appropriate planting.

We have also included lists of ecologically valuable grasses, forbs and woody species specifically for use in erosion control and rehabilitation projects in early successional environments. Before selecting a planting list, it is important to survey surrounding natural community composition, alongside site specific soils, elevation, and topography, to determine what natural community planting list, and what individual species, will be most ecologically appropriate to use on a site (see Appendix B). The range of each native species within Vermont has been inferred using the Native Plant Trust's GoBotany webpage (https://gobotany.nativeplanttrust.org/) and is described in terms of the Biophysical Regions of Vermont in which they occur.

Of course, this section does not provide an exhaustive list of appropriate native species, but simply an overview of Vermont's common and ecologically important species and the conditions that they are most likely to thrive in. Provided that they are native, not rare or state-listed, and ecologically appropriate to a site, planters can incorporate species not listed here into their plantings. Consult Appendices B & C for information on identifying site conditions, species ranges, and local ecotypes. The Wildflower Search website (https://wildflowersearch.org/) can also be used to help generate plant lists for your site location.

This section does not provide specific instructions on site preparation (Appendix E) or a list of regional native plant suppliers (Appendix F). In addition to procuring these species from nurseries, ANR staff may choose to transplant ecologically appropriate plants from nearby sites.

Defining Terms and Notes

Successional Status:

E - Early Successional

M - Middle Successional

L - Late Successional

L* - Late Successional under specific site conditions

Biophysical Regions of Vermont:

CH = Champlain Hills

CV = Champlain Valley

NEHL = Northeastern Highlands

NGM = Northern Green Mountains

NVP = Northern Vermont Piedmont

SGM = Southern Green Mountains

SVP = Southern Vermont Piedmont

TM = Taconic Mountains

VV = Vermont Valley

D1. Landscaping Plants for Developed Areas

The following list can be used at parks in areas with developed lands. Staff can also refer to Appendix E for more information on tree planting on developed lands. The table below includes a mix of native and non-native herbaceous species that do well in park like settings and are favored for their aesthetics. Additional species for consideration in park settings for both developed and intact forest systems can be found in the native erosion control lists and restoration lists that follow.

Herbaceous Species for Developed Area Landscapes		
Common Name	**Latin Name**	**Locality Status**
Wild columbine	*Aquilegia canadensis*	native
Rock harlequin	*Capnoides sempervirens*	native
Cardinal flower	*Lobelia cardinalis*	native
Asters	*Symphyotrichum cordifolius, Symphyotrichum novae-angliae, and Eurybia divaricata*	native
Swamp milkweed	*Asclepias incarnata*	native
Wild ginger	*Asarum canadense*	native
White turtlehead	*Chelone glabra*	native
Boneset	*Eupatorium perfoliatum*	native
Wild bergamont	*Mondarda fistulosa*	native
Goldenrod	*Solidago caesia, canadensis, flexicaulis, and nemoralis*	native
Sunflower	*Helianthus annus*	non-native but unlikely to escape
Nasturium	*Tropaeolum majus*	non-native but unlikely to escape
Hostas	*Hosta spp.*	non-native but unlikely to escape
Pansies	*Viola spp.*	non-native but unlikely to escape
Marigolds	*Tagetes spp.*	non-native but unlikely to escape
Partridge pea	*Chamaecrista fasciculata*	non-native but unlikely to escape
Cleome	*Cleome hassleriana*	non-native but unlikely to escape
Zinnias	*Zinnia elegans*	non-native but unlikely to escape
Cosmos	*Cosmos bipinnatus*	non-native but unlikely to escape
Petunia	*Petunia sp.*	non-native but unlikely to escape
Snapdragons	*Antirrhinum majus*	non-native but unlikely to escape
For more native plant species for use in pollinator and landscape gardens review the following tables: **Native Forbs for Erosional Control & Conservation Mix**, **Native Grasses for Erosion Control & Conservation Mix, Upland Early Successional Shrubs, Wetland Forbs for Wildlife, Wetland Shrubs for Wildlife.**		

D2. Erosion Control & Conservation Mixes

Whether they take place on roadsides, former farmland, log landings, or other open environments, many planting projects both require and provide the opportunity for the rapid proliferation of early successional plants. The following plant lists have been constructed to allow planters to efficiently accomplish erosion control naturalization projects in sunny, early successional upland and wetland environments using native species with sustained wildlife benefits.

We have included distinct lists of erosion-controlling grasses, sedges, and forbs that provide wildlife benefits, and early successional woody plants that control erosion and provide wildlife benefits.

To increase the success of the native early successional herbaceous plantings, planters can use several noninvasive non-native grass species as initial soil-stabilizing cover crops. A non-exhaustive list of appropriate non-native cover crop species is also included below.

This section draws heavily from the research done by the creators of the New England Transportation Consortium's 2023 report *A Roadmap for New England DOTs to Transition to Sustainable Roadside Practices for Strengthening Pollinator Habitat and Health* and the 2016 *Planting Guidance for the Revegetation of Riparian Areas in Vermont*.

Native Plants to Avoid When Choosing a Conservation Mix

The following species are commonly available in seed mixes and are tracked on the Vermont Rare and Uncommon Native Vascular Plants List, which is produced by Vermont Fish & Wildlife Department's Natural Heritage Inventory. Planting rare and uncommon species may harm natural populations by causing loss of genetic fitness through inbreeding with non-locally adapted genotypes. Additionally, planting rare species can obscure biogeographic patterns and prevent botanists and conservationists from understanding the true rarity of imperiled species. Some exceptions involving planting of local ecotype uncommon (S3) species may be appropriate in consultation with the State Botanist.

Herbaceous Plants to Avoid: Sundial lupine (*Lupinus perennis*)**,** Canada milk vetch (*Astragalus canadensis*), yellow wild indigo (*Baptisia tinctoria*), broad-leaved mountain mint (*Pyncnanthemum muticum*), round-headed bush-clover (*Lespedeza capitata*), switch panicgrass (*Panicum virgatum*), rough-leaved goldenrod (*Solidago patula*), swamp thistle (*Cirsium muticum*), fall sneezeweed (*Helenium autumnale*), Indian grass (*Sorghastrum nutans*), great St. John's wort (*Hypericum ascyron*), beachgrass (*Ammophila breviligulata*), downy wood mint (*Blephilia ciliata*), dotted horsemint (*Monarda punctata*), blunt leaved milkweed (*Asclepias amplexicaulis)*, whorled milkweed (*Asclepias verticillata*), ox-eye (*Heliopsis helianthoides*), butterflyweed (*Asclepias tuberosa*), wild senna (*Senna hebecarpa*), (*Penstemon hirsutus*), and narrow blue-eyed grass (*Sisyrinchium angustifolium*).

Shrubs to Avoid: Eastern shadbush (*Amelanchier canadensis*), American hazelnut (*Corylus americana*), and red mulberry (*Morus rubra*).

The Vermont Rare and Uncommon Native Vascular Plants List (Appendix H) provides a comprehensive inventory of rare and uncommon plants found in Vermont.

Erosion Control and Conservation Mix Lists

The following lists can be used to create erosion control and conservation seed mixes. When developing a conservation seed mix using the plant lists below, consider that your mix should be about 65-70% cover crop, 15% grasses, and 15% forbs. Also consider the moisture regime at your site. The plants listed will work in a mix of dry, mesic, and wet sites.

Nonnative Upland Erosion Control & Stabilization Cover Crop Grasses			
Common Name	**Scientific Name**	**Distribution**	**Ideal Planting Location & Comments:**
Grain oats	*Avena sativa*	Nonnative	Wet to dry sites. Cover crop planted in **late May to mid-August.**
Red fescue	*Festuca rubra*	Nonnative	Dry sites. Cover crop planted **late May to mid-August.**
Winter rye	*Secale cereale*	Nonnative	Dry to wet sites with low fertility. Cover crop planted in **late August to mid-May**.
Annual ryegrass	*Lolium multiflorum*	Nonnative	Mesic to dry sites. Cover crop planted **late May to mid-August.**

Native Graminoids for Erosion Control & Conservation Mix			
Common Name	**Scientific Name**	**Distribution**	**Ideal Planting Location & Comments:**
Autumn bentgrass (cover crop)	*Agrostis perennans*	Statewide	Mesic to wet sites. **Cover crop for sites planted late August to mid-May.**
Big bluestem	*Andropogon gerardii*	Statewide	Dry to mesic sites.
Sallow Sedge	*Carex lurida*	Statewide	Wet sites.
Common Fox Sedge	*Carex vulpinoides*	Statewide	Wet sites.
Poverty Grass	*Danthonia spicata*	Statewide	Dry sites.
Deer-tongued Rosette Panicgrass	*Dichanthelium clandestinum*	Statewide	Dry sites.
Virginia wildrye	*Elymus virginicus*	Statewide	Wet to dry sites.
Tufted lovegrass	*Eragrostis pectinacean*	Statewide	Dry to mesic sites.
Little bluestem	*Schizachyrum scoparium*	Statewide	Mesic to dry sites.

Native Forbs for Erosional Control & Conservation Mix			
Common Name	**Scientific Name**	**Distribution**	**Ideal Planting Location & Comments:**
Golden Alexander	*Zizia aurea*	Statewide	Dry to wet sites.
Columbine	*Aquilegia candadensis*	Statewide, less common in NEHL	Dry sites.
Common Milkweed	*Asclepias syriaca*	Statewide, less common in NEHL	Dry to mesic sites.
New York Aster	*Symphotrichium nova-belgii*	NVP, SVP	Dry to wet sites.
Fireweed	*Chamaenerion angustifolium*	Statewide	Mesic.
Wild Bergamot	*Monarda fistulosa*	Statewide, less common in Northernmost VT	Dry to mesic sites.
Tall Windflower	*Anemone virginiana*	Statewide	Mesic.
Calico American Aster	*Symphotrichium lateriflorum*	Statewide	Dry sites.
Tall Lettuce	*Lactuca canadensis*	Statewide	Mesic to dry sites.
Showy tick-trefoil	*Desmodium canadense*	Statewide (less common in the NEK)	Mesic to wet sites. **Nitrogen fixer.**
Wild Strawberry	*Fragaria virginiana*	Statewide	Mesic sites.
Narrow-leaved mountain mint	*Pycnanthemum tenuifolium*	Statewide	Mesic to dry sites.
Boneset	*Eupatorium perfoliatum*	Statewide	Wet to mesic sites.
The combination of Vermont native forbs within this list allows sites to provide wildlife benefits throughout the growing season.			

D3. Plants for Restoration Plantings

The plant lists provided are designed to guide the restoration and reestablishment of plant communities, considering both site conditions and community types. These lists include species recommended for planting in open sites on wetlands and uplands, as well as those associated with natural community formations like Northern Hardwood Forest, Oak-Pine-Northern Hardwood Forest, Spruce-Fir Northern Hardwood, and forested wetlands, including floodplains.

When selecting species, it is essential to understand the specific needs of each plant. For instance, some plants, such as red spruce, can be planted under existing trees without much concern for space or light, while others, like white ash, red oak, and white pine, require large gaps in the canopy to establish and grow to their full potential. Additionally, many of these species are adapted to disturbance and may not thrive in intact forests without the disruption they need to regenerate.

Some species on these lists, particularly the forbs, may be considered specialty species that are not commonly available in nurseries. However, an effort has been made to ensure that many are accessible either as seeds or whole plants. In some cases, such as with ferns or plants that spread through rhizomes, they can be transplanted directly from nearby sites. Resistant genotypes should be prioritized for species currently threatened by non-native insects and pathogens, ensuring greater long-term resilience.

Along with considering site conditions, it is important for project managers to factor in shade tolerance and the regeneration needs of each species. The success of planting efforts will depend on selecting the right species for the site's conditions and understanding how each plant will respond to different levels of light, disturbance, and competition.

Early Successional Sites

Upland Early Successional Trees			
Common Name	**Scientific Name**	**Distribution**	**Ideal Planting Location & Comments:**
White Pine	*Pinus strobus*	Statewide, mostly below 2000 ft.	Highly adaptable to dry to wet soils. **Consider:** can form dense, shady stands rapidly on sodded soils. Also prone to white pine weevil damage when planted in the open.
Black Cherry	*Prunus serotina*	Statewide	Mesic, coarse, acid soils.
Black Birch	*Betula lenta*	Low elevations in Southern VT, CV, NVP, and SVP	Mesic to wet-mesic, well-drained soils, rocky or shallow soils.
Yellow Birch	*Betula alleghaniensis*	Statewide, mostly below 3000 ft., abundance increases with elevation	Needs exposed mineral soil, or nurse logs to germinate. Wet-mesic well-drained soils. Abundant in areas with regular disturbance, past fire disturbance.
Quaking Aspen	*Populus tremoloides*	Statewide	Adaptable to dry to mesic-wet soils, shallow to deep soils. **Consider**: spreads clonally, forms shady thickets.
Staghorn Sumac	*Rhus typhina*	Statewide	Drier, rocky-gravelly soils. **Consider:** spreads clonally, forms dense shady thickets.

Upland Early Successional Shrubs			
Common Name	**Scientific Name**	**Distribution**	**Ideal Planting Location & Comments:**
Beaked Hazelnut	*Corylus cornuta*	Statewide at low to moderate elevations	Dry-mesic to mesic sites, thrives with some enrichment.
Low Sweet Blueberry	*Vaccinium angustifolium*	Statewide	Dry to mesic, shallow, well-drained acidic soils.
Flowering raspberry	*Rubus odoratus*	Statewide	Mesic to wet-mesic sites, full sun to part shade. **Consider:** spreads clonally and forms dense thickets.
Chokecherry	*Prunus pensylvanica*	Statewide, from up to 2800 ft.	Mesic acid soils.

Open Wetland Sites

Wetland Forbs & Graminoids for Wildlife – Open Wetland Sites			
Common Name	**Scientific Name**	**Distribution**	**Ideal Planting Location & Comments:**
Blue Vervain	*Verbena hastata*	Statewide	Wet sites.
Swamp milkweed	*Asclepias incarnata*	Statewide	Mesic to wet sites.
Hemp Dogbane	*Apocynum cannibinum*	Statewide	Wet sites.
New England Aster	*Symphyotrichum nova-angliae*	Statewide, less common in Northernmost VT	Dry to wet sites, high salinity sites.
Purple-stemmed aster	*Symphyotrichum puniceum*	Statewide	Wet sites.
Canada Lily	*Lilium canadense*	Statewide	Wet sites.
Cardinal Flower	*Lobelia cardinalis*	Statewide, less common in NGM, NVP, and NEHL	Wet sites.
Golden Alexander	*Zizia aurea*	Statewide	Dry to wet sites, high salinity sites.
Hooded Skullcap	*Scutellaria galericulata*	Statewide	Wet sites.
New York Aster	*Symphotrichum nova-belgii*	NVP, SVP	Dry to wet sites.
Turtlehead	*Chelone glabra*	Statewide	Wet sites.
Soft rush	*Juncus effusus*	Statewide	Wet sites.
Bluejoint grass	*Calamagrostis canadensis*	Statewide	Wet sites.
Sallow sedge	*Carex lurida*	Statewide	Wet sites.
Bristly sedge	*Carex comosa*	Statewide	Wet sites.
Fowl manna grass	*Glyceria striata*	Statewide	Wet sites.
The combination of Vermont native herbaceous species within this list allows sites to provide wildlife benefits throughout the growing season. For a wider range of appropriate species, see the 2023 report *A Roadmap for New England DOTs to Transition to Sustainable Roadside Practices for Strengthening Pollinator Habitat and Health.*			

Wetland Shrubs for Wildlife – Open Wetland Sites			
Common Name	**Scientific Name**	**Distribution**	**Ideal Planting Location & Comments:**
Common pussy willow	*Salix discolor*	Statewide	Tolerates extended duration and moderately frequent flooding. Good for erosion control.
Silky willow	*Salix sericea*	Statewide	Tolerates frequent flooding. Sandy, gravelly, or cobbly shorelines.
Bebb's willow	*Salix bebbiana*	Statewide	Tolerates shorter duration flooding.
Shining willow	*Salix lucida*	Statewide	Consistently moist to wet soils.
Sandbar willow	*Salix exigua ssp. interior*	SVP, CV, and CH	Tolerates frequent shorter duration flooding. Sandy soils.
Wooly-headed willow	*Salix eriochephala*	Statewide	Tolerates shorter duration annual flooding. Sand to gravel soils
Red Osier Dogwood	*Cornus sericea*	Statewide	Tolerates regular flooding, can tolerate some growing season flooding.
Silky Dogwood	*Cornus amomum*	Statewide, less common in NEHL and NGM	Tolerates occasional flooding, clay soils.
Speckled alder	*Alnus incana spp. rugosa*	Statewide	Tolerates shorter duration, annual flooding. Adaptable to a range of soil textures.
Wild raisin	*Viburnum nudum*	Statewide	Tolerates occasional flooding, consistently wet soil.
Buttonbush	*Cephalanthus occidentalis*	Statewide	Tolerates regular flooding.
This is a list of colonizing shrubs suitable for rapid restoration of woody riparian vegetation in Vermont, extracted from the larger *Planting Guidance for the Revegetation of Riparian Areas in Vermont.* This document, alongside the "Forested Wetland Communities" section below, can be consulted for a wider range of native species appropriate for wetland restoration in Vermont.			

Upland Forest Communities

Northern Hardwood Forest Formation Plantings

This is Vermont's foremost matrix community. It dominates the cool and mesic glacial till sites that are widely distributed across Vermont, and generally occurs below 2700 feet. Above this point, and in colder areas generally, Spruce-Fir-Northern Hardwood Forest communities naturally dominate. Conversely, Oak-Pine-Northern Hardwood Forest communities dominate warmer and drier areas of Vermont below Northern Hardwood Forests at the state's lowest elevations. The plant lists here can be used for various goals. If trying to reestablish a natural community in a disturbed environment, consider successional plantings.

Forbs – Northern Hardwood Upland Forest Communities				
Common Name	**Scientific Name**	**Distribution**	**Succession**	**Ideal Planting Location & Comments:**
Intermediate Wood Fern	*Dryopteris intermedia*	Statewide	M/L	Excessively drained to poorly drained acid soils.
Christmas Fern	*Polystichum acrostichoides*	Statewide	M/L	Well-drained soils with some enrichment.
Sarsaparilla	*Aralia nudicaulis*	Statewide	M/L	Adaptable to moist or relatively dry conditions. **Consider:** This plant can be mistaken for American ginseng which has a palmate leaf structure.
Marginal Wood Fern	*Dryopteris marginalis*	Statewide	M/L	Moist, well-drained soils with some enrichment.
All these species are perennials with either rhizome (ferns) or tap root structures and take time to spread and establish. Ferns and wild sarsaparilla can be transplanted where they are abundant and adjacent to the planting site.				

Shrubs – Northern Hardwood Upland Forest Communities				
Common Name	**Scientific Name**	**Distribution**	**Succession**	**Ideal Planting Location & Comments:**
Striped Maple	*Acer pensylvanicum*	Statewide	M/L	Moist acid soils, cool areas like north-facing slopes. **Consider:** This species can form a recalcitrant understory, so only plant where this is not an issue for project goals.
Hobblebush	*Viburnum lantanoides*	Statewide	M/L	Moist, coarse, acid soils. **Consider:** This species can form a recalcitrant understory, so only plant where this is not an issue for project goals.
Shadbushes	*Amelanchier spicata* *A. arborea* *A. laevis*	Statewide	E/M/L	A. spicata: grows well in rocky soils, thicket forming A. arborea: Adaptable. A. laevis: dry-mesic to wet-mesic sandplain soils.
Dogwoods	*Cornus rugosa* *Cornus alternifolia*	Statewide*, C. rugosa* less common in NEHL	M/L	Overall: Cool, north-facing slopes. *C. alternifolia:* Well-drained, moist deep soils. *C. rugosa:* well-drained, drier, sandy soils.
Beaked Hazelnut	*Corylus cornuta*	Statewide at low to moderate elevations	E/M/L*	Most persistent on mesic sandy loams. **Consider:** Spreads through clonal sprouting.

Trees – Northern Hardwood Upland Forest Communities				
Common Name	**Scientific Name**	**Distribution**	**Succession**	**Ideal Planting Location & Comments:**
Sugar Maple	*Acer saccharum*	Statewide	M/L	Moist well-drained loams with some enrichment, concave slopes.
American Beech	*Fagus grandifolia*	Statewide	M/L	Adaptable, thrives on well drained sites, convex slopes. **Consider:** Spreads aggressively through clonal sprouting. BBD kills many mature trees and promotes sprouting. High sapling mortality in future due to BLD. Choose resistant genotypes.
Yellow Birch	*Betula alleghaniensis*	Statewide, mostly below 3000 ft, abundance increases with elevation	E/M/L*	Needs exposed mineral soil, or nurse logs to germinate. Wet-mesic well-drained soils. Abundant in areas with regular disturbance, past fire disturbance.
White Ash	*Fraxinus americana*	Statewide, less common in NEHL	E/M/L*	Mesic soils, concave slopes. Persists in enriched areas. **Consider:** Mass mortality from EAB in near future.
Eastern Hemlock	*Tsuga canadensis*	Statewide below 2400 ft., abundant below 1800 ft., rare in NEHL	M/L*	Needs exposed mineral soil, or nurse logs to germinate. Persists where these conditions are consistently available. **Consider:** Significant mortality from HWA in future.
Basswood	*Tilia americana*	Statewide	M/L	Enriched areas, moist soils with shallow hardpans.
Red Maple	*Acer rubrum*	Statewide	E/M	Adaptable. Thrives on convex slopes. Thrives in moist loams, tolerable of dry and nutrient poor soil.
White Pine	*Pinus strobus*	Statewide, mostly below 2000 ft.	E/M/L*	Persists on well-drained, sandy and drier soils.
Red Spruce	*Picea rubens*	Statewide, mostly above 1500 ft.	M/L	Cool areas, moist and shallow soils
Red Oak	*Quercus rubra*	Statewide, below 2500 ft. in S. VT, 1500 ft. in N. VT	M/L*	Sunnier, drier, and well-drained sites on south or west facing slopes. Most persistent on drier NHF sites but tolerates more mesic conditions.

Oak-Pine Northern Hardwood Forest Formation Plantings

This matrix community dominates Vermont's drier and warmer areas, which are subject to more frequent and more prolonged droughts than other regions of the state. These communities can form large stands in the state's lowest elevations or form small patches on dry south-facing slopes and ridgetops below (at most) 2200 feet. Drought and disturbance are important ecological process in these areas, and a given Oak-Pine-Northern Hardwood Forest community's composition is, in addition to local bedrock characteristics, influenced greatly by in the frequency and intensity of drought that it experiences. Consequently, a site's drought vulnerability and bedrock should be considered when selecting species for planting. Since most of these species are disturbance adapted, they may not succeed in an intact forest with a shady canopy, thick forb layers, or leafy understories underlain with thick organic soils.

Forbs – Oak-Pine Northern Hardwood Upland Forest Communities				
Common Name	**Scientific Name**	**Distribution**	**Succession**	**Ideal Planting Location & Comments:**
Woodland Sedge	*Carex pensylvanica*	Statewide, less common in N. CV and CH	E/M/L	Well-drained soils, drier and open sites where earthworms or deer browse is not a problem.
Poverty grass	*Danthonia spicata*	Statewide	E/M/L*	Persists on drier sites with open canopies.
Bracken Fern	*Pteridium aquilinum*	Statewide	E/M	Adaptable, thrives on well-drained soils in full sunlight.
Marginal Wood Fern	*Dryopteris marginalis*	Statewide	M/L	Moister, well-drained soils with some enrichment.
Sessile-leaved bellwort	*Uvularia sessilifolia*	Statewide	M/L	Dry to mesic shady sites.

Shrubs – Oak-Pine Northern Hardwood Upland Forest Communities				
Common Name	**Scientific Name**	**Distribution**	**Succession**	**Ideal Planting Location & Comments:**
Maple-leaved Viburnum	*Viburnum acerifolium*	Statewide, less common in northernmost VT	M/L	Adaptable to dry to moist well-drained soils. **Consider:** Spreads through rhizomes, thicket-forming.
Low sweet blueberry	*Vaccinium angustifolium*	Statewide	E/M	Dry to mesic shallow, well-drained acidic soils. Most persistent in open woodlands or other areas with dry, sunny conditions.
Witch Hazel	*Hamamelis virginiana*	Statewide, less common in NEHL and CH	M/L	Dry and warm sites. Shade tolerant.
Shadbushes	*Amelanchier sanguinea* *A. spicata* *A. arborea* *A. laevis*	Statewide, *A. sanguinea* less common in NGM	E/M/L	Overall, partial shade to full sun, drier soils. *A. sanguinea*: grows well on exposed rock. *A. spicata:* grows well in rocky soils, thicket forming. *A. arborea:* Adaptable. *A. laevis*: dry-mesic to wet-mesic sandplain soils.
Sweet fern	*Comptonia peregrina*	CV and southern VT	E/M	Open woodlands and margins, meadows, dry to mesic, sandy acid soils. Good colonizer of barren nutrient-poor soils. Full sun or partial shade. Tolerates drought.

Trees – Oak-Pine Northern Hardwood Upland Forest Communities				
Common Name	**Scientific Name**	**Distribution**	**Succession**	**Ideal Planting Location & Comments:**
Red Oak	*Quercus rubra*	Statewide, below 2500 ft. in S. VT, 1500 ft. in N. VT	M/L	Sunny, dry and well-drained sites on south/west-facing slopes. **Adaptable to more mesic conditions.**
White Oak	*Quercus alba*	Lower elevations, rare in N&SGM, NEHL and NVP	M/L	Requires sunny, dry-somewhat dry well-drained sites, or wet clay soils.
Shagbark Hickory	*Carya ovata*	Lower elevations, rarely occurs in NEHL & NVP	M/L	Deeper well-drained soils. Thrives on sites with some enrichment and slightly elevated moisture.
Bitternut Hickory	*Carya cordiformis*	Lower elevations, rarely occurs in NEHL & NVP	M/L	Dry-mesic to conditions. Loamy or gravelly soils with some enrichment.
Hophornbeam	*Ostrya virginiana*	Statewide at lower elevations	M/L	Dry-mesic to mesic well-drained sites, valley bottoms, lower slopes.
Chestnut Oak	*Quercus montana*	VV, CV, extreme Southeastern VT	M/L*	Dry to dry-mesic, rocky soils on south/west-facing slopes. Tolerates infertile sites. Persists in especially dry environments.
White Pine	*Pinus strobus*	Statewide, mostly below 2000 ft.	E/M/L*	Persists on well-drained, drier and sandy soils.
Black Birch	*Betula lenta*	Low elevations in southern VT, CV, NVP, and SVP	E/M/L*	Well-drained soils, rocky or shallow soils. Persists on sites with slightly elevated moisture.
Sugar maple	*Acer saccharum*	Statewide	M/L	Moist well-drained loams with some enrichment, concave slopes. Plant in cooler sites.
White Ash	*Fraxinus americana*	Statewide, less common in NEHL	E/M/L*	Mesic soils, concave slopes. Persists in enriched areas. **Consider:** Mass mortality from EAB in near future.
Eastern Hemlock	*Tsuga canadensis*	Statewide below 2400 ft., abundant below 1800 ft., less common in NEHL	M/L*	Needs exposed mineral soil, or nurse logs to germinate. Persists where these conditions are consistently available. **Please consider:** Significant mortality from HWA in future.
Since most of these species are disturbance adapted, they may not succeed in an intact forest with a shady canopy, thick forb layers, or leafy understories underlain with thick organic soils.				

Spruce-Fir Northern Hardwood Forest Formation Plantings

These forests dominate Vermont's coldest areas. They occur on mountains above 2500 feet, and in sites that receive cold air drainage across the state. Many species in this community are softwoods adapted to thrive in shallow, acidic, cool, and infertile soils. That said, several Northern Hardwood species play important roles in Spruce-Fir communities that occur on enriched sites at lower elevations. Sites with these characteristics offer opportunities to incorporate these species into plantings to bolster site complexity.

Forbs – Spruce-Fir Northern Hardwood Upland Forest Communities				
Common Name	**Scientific Name**	**Distribution**	**Succession**	**Ideal Planting Location & Comments:**
Common Wood Sorrel	*Oxalis montana*	Statewide	M/L	Adaptable, highly shade tolerant.
Intermediate Wood Fern	*Dryopteris intermedia*	Statewide	M/L	Excessively drained to poorly drained acid soils.
Marginal Wood Fern	*Dryopteris marginalis*	Statewide	M/L	Moist, well-drained soils with some enrichment.
Canada mayflower	*Maianthemum canadense*	Statewide	M/L	Adaptable to different moisture conditions, intolerant of highly acidic soils.

Shrubs – Spruce-Fir Northern Hardwood Upland Forest Communities				
Common Name	**Scientific Name**	**Distribution**	**Succession**	**Ideal Planting Location & Comments:**
American Mountain Ash	*Sorbus americana*	Statewide in high elevations or cooler climates	M/L	Full to partial sun. Moist poorly-drained to dry well-drained acid to neutral soils. Cooler sites. Soils with organic matter.
Lowbush blueberry	*Vaccinium angustifolium*	Statewide	E/M/L	Moist poorly-drained to well-drained acid soils. Cooler sites.
Hobblebush	*Viburnum lantanoides*	Statewide	M/L	Moist, coarse, acid soils.
Striped Maple	*Acer pensylvanicum*	Statewide	M/L	Moist acid soils.
Mountain Maple	*Acer spicatum*	Statewide	M/L	Moist enriched soils.

Trees – Spruce-Fir Northern Hardwood Upland Forest Communities				
Common Name	**Scientific Name**	**Distribution**	**Succession**	**Ideal Planting Location & Comments:**
Red Spruce	*Picea rubens*	Statewide, Mostly above 1500 ft.	M/L	Cool areas, moist and shallow acidic soils.
Balsam Fir	*Abies balsamea*	Higher elevations and cold pockets in NGM, SGM, and NEHL	M/L	Cool areas, moist and shallow acidic soils. Somewhat vulnerable to climate change.
Heart-leaved Paper birch	*Betula cordifolia*	Higher elevations and cold pockets in NGM, SGM, and NEHL	M/L	Cool areas, moist and somewhat enriched soils. Abundant in areas with regular disturbance, past fire disturbance.
Paper birch	*Betula papyrifera*	Statewide	E/M/L	Adaptable. Abundant in areas with regular disturbance, past fire disturbance.
Yellow Birch	*Betula alleghaniensis*	Statewide, mostly below 3000 ft. Abundance increases with elevation.	E/M/L*	Needs exposed mineral soil, or nurse logs to germinate. Wet-mesic well-drained soils. Abundant in areas with regular disturbance, past fire disturbance.
Black Spruce	*Picea mariana*	NEHL, high elevations in NGM	M	Common in relatively wet areas of northern lowland and montane Spruce-Fir communities, favors acidic soils. Vulnerable to climate change.
White Pine	*Pinus strobus*	Statewide	E/M/L*	Persists on well-drained sites in lowland Spruce-Fir communities
White Spruce	*Picea glauca*	NEHL and NVP	E/M	Germinates best on exposed mineral soil or thin organic soils.
Pin Cherry	*Prunus pensylvanica*	Statewide up to 4000 ft.	E/M	Highly adaptable, pioneer species.
Sugar maple	*Acer saccharum*	Statewide, most common below 2700 ft.	M/L	Moist well-drained loams with some enrichment, concave slopes. **Warmer sites.**
Red Maple	*Acer rubrum*	Statewide, most common below 2700 ft.	E/M	Adaptable. Thrives on convex slopes. Thrives in moist loams, tolerable of dry and nutrient poor soil. **Warmer sites.**
American Beech	*Fagus grandifolia*	Statewide, most common below 2700 ft.	M/L	Adaptable, thrives on well drained sites, convex slopes. **Please consider:** Spreads aggressively through clonal sprouting. BBD kills many mature trees and promotes sprouting. High sapling mortality in future due to BLD. Choose resistant genotypes. **Warmer sites.**

Forested Wetland Communities

Floodplain Forest Plantings

Variations in the composition of floodplain forests are fundamentally determined by variations in flood regimes between sites. Each species within these lists is therefore accompanied by a description of its flood tolerances so that floodplain plantings can be the most successful.

Herbaceous plants – Floodplain Forested Wetland Communities			
Common Name	**Scientific Name**	**Distribution**	**Ideal Planting Location & Comments:**
Sensitive Fern	*Onoclea sensibilis*	Statewide	Sites with extended duration flooding.
Ostrich Fern	*Matteuccia struthioperis*	Statewide	Sites with shorter duration, annual flooding.
Wood nettle	*Laportea canadensis*	Statewide	Sites with annual flooding. **Consider:** Causes contact dermatitis.
False nettle	*Boehmeria cylindrica*	Statewide, less common in Northernmost VT	Sites with annual flooding.

Shrubs – Floodplain Forested Wetland Communities			
Common Name	**Scientific Name**	**Distribution**	**Ideal Planting Location & Comments:**
Chokecherry	*Prunus virginiana*	Statewide	Well-drained, acid soils. Tolerates short duration flooding.
Winterberry Holly	*Ilex verticillata*	Statewide, less common in NGM	Frequently waterlogged sites. Dioecious, needs male and female plants to produce berries.
Riverbank Grape	*Vitis riparia*	Statewide	Adaptable vine. **Consider:** Spreads aggressively in full sun.
Dogwoods	*Cornus alternifolia, Cornus amomum, Cornus sericea*	Statewide	*C. alternifolia* does well in deep, well drained soils. Infrequent flooding. Floodplains and terraces. Partial shade to full sun. *C. amomum* and *C. sericea* do well in wet soils. Wetlands, moist shores.
Virgin's Bower	*Clematis virginiana*	Statewide	Sun and part shade. Moist woods and along shores. Vine.
Virginia creeper	*Parthenocissus quinquefolia*	Statewide	Adaptable, prefers well-drained sites. Vine.

Trees – Floodplain Forested Wetland Communities			
Common Name	**Scientific Name**	**Distribution**	**Ideal Flood Regime and Planting Location:**
Silver Maple	*Acer saccharinum*	Statewide	Areas with frequent, extended flooding. Moderate to lowest gradient sites on large rivers, deltas, lakeshores.
Green Ash	*Fraxinus pennsylvanica*	CV and Missisquoi river	Areas with frequent, extended flooding. Lower gradient sites on large rivers, deltas, lakeshores. **Consider:** Mass mortality from EAB in near future (already occurring in Grand Isle County).
Eastern Cottonwood	*Populus deltoides*	Statewide, less common in NEHL	Areas with shorter duration-fooding, dormant season flooding. Lake shores and large rivers.
Elms	*Ulmus americana Ulmus rubra*	Statewide below 2000 ft.	Areas with shorter duration flooding, *U. americana* better tolerates extended flooding **Consider:** Most elms die within 30 years from Dutch Elm Disease.
Black willow	*Salix nigra*	Statewide	Areas with extended flooding and consistently high moisture.
Swamp White Oak	*Quercus bicolor*	CV	Tolerates extended flooding, prefers acid soils.
American Sycamore	*Platanus occidentalis*	CV and SVP	River cobble and gravel shores (requires full sun and mineral soil to germinate).
Sugar maple	*Acer saccharum*	Statewide	Moderate to high gradient sites and terraces with infrequent, short flooding. Well-drained soils.
White Ash	*Fraxinus americana*	Statewide, less common in NEHL	Well-drained sites with infrequent, short flooding. Moderate-high gradients and terraces.
Musclewood	*Carpinus caroliniana*	Statewide	Well drained sites with infrequent, short flooding.
Basswood	*Tilia americana*	Statewide	Sites with infrequent, short flooding. Moderate-high gradients and terraces

Boreal Floodplain Forest Plantings

In Northeastern Vermont, floodplain community composition is substantially different, particularly in rivers and streams that receive cold air drainage and are subject to ice scours. Boreal species form an important component of these floodplain communities. Appropriate species for these sites are included in the planting list below.

Forbs – Boreal Floodplain Forested Wetland Communities		
Common Name	**Scientific Name**	**Ideal Flood Regime and Planting Location:**
Sensitive Fern	*Onoclea sensibilis*	Sites with extended duration flooding.
Ostrich Fern	*Matteuccia struthioperis*	Sites with shorter duration, annual flooding.

Shrubs – Boreal Floodplain Forested Wetland Communities		
Common Name	**Scientific Name**	**Ideal Flood Regime and Planting Location:**
Speckled alder	*Alnus incana*	Adaptable to a range of soil fertility, tolerates shorter duration flooding.
Beaked Hazelnut	*Corylus cornuta*	Drier sites with infrequent flooding. **Consider:** spreads through clonal sprouting.

Trees – Boreal Floodplain Forested Wetland Communities		
Common Name	**Scientific Name**	**Ideal Flood regime and Planting Location:**
Balsam Fir	*Abies balsamea*	Areas with occasional ice scour and flooding.
Black Ash	*Fraxinus nigra*	Adaptable, tolerates excessive moisture and short duration flooding. **Consider:** Mass mortality from EAB in near future.
Northern White Cedar	*Thuja occidentalis*	Sites with some enrichment, does not tolerate extended flooding. **Consider:** Challenge to regenerate due to snowshoe hare and deer herbivory.
Balsam Poplar	*Populus balsamifera*	Highly tolerant of extended flooding, requires wet, enriched soils.

D4. Adaptation Planting Recommendations

The following table includes species with peer-reviewed literature on genetics and seed transfer distance recommended for adaptation plantings. This table is adapted from The Forest Service National Center for Reforestation, Nurseries, and Genetic Resources. It is important to note that this is not an exhaustive list, however, please be advised to research species not on this list to determine recommended transfer distances for species and genotypes.

Eastern White Pine (*Pinus strobus*) Link to full species profile: https://rngr.net/publications/tpn/65-2/eastern-white-pine-guidance-for-seed-transfer-within-the-eastern-united-states/	
Genetics	Genetic diversity: High.[1,2,3] Gene flow: High.[1,4]
Insects and Diseases	White pine blister rust (major), Heterobasidion root disease, Armillaria root rot. White pine weevil (major), white pinecone borer, white pine sawfly.
Maximum Transfer Distance	Seed sources originating up to 200 miles south of the planting site will likely perform as well or better than local sources.[5,6]

[1]Nadeau, S.; Godbout, J.; Lamothe, M.; Gros-Louis, M.-C.; Isabel, N.; Ritland, K. 2015. Contrasting patterns of genetic diversity across the ranges of Pinus monticola and P. strobus: a comparison between eastern and western North American postglacial colonization histories. American Journal of Botany. 102(8): 1342–1355.

[2]Zinck, J.W.R.; Rajora, O.P. 2016. Post-glacial phylogeography and evolution of a wide-ranging highly-exploited keystone forest tree, eastern white pine (Pinus strobus) in North America: single refugium, multiple routes. BMC Evolutionary Biology. 16: 56.

[3]Rajora, O.P.; Eckert, A.J.; Zinck, J.W.R. 2016. Single-locus versus multilocus patterns of local adaptation to climate in eastern white pine (Pinus strobus, Pinaceae). PLoS ONE 11(7): e0158691

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Northern Red Oak (*Quercus rubra)* Link to full species profile: https://rngr.net/publications/tpn/65-1/northern-red-oak-guidance-for-seed-transfer-within-the-eastern-united-states/	
Genetics	Gene flow: consistently high gene flow via pollen.[1,2,3] Seed: high gene flow on average but may be reduced locally when dispersal is limited.[2]
Insects and Diseases	Spongy moth, two-lined chestnut borer Oak wilt
Maximum Transfer Distance	No specific transfer distances have been calculated, but red oak has demonstrated a high tolerance to long-distance transfer.[4]

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Yellow Birch (*Betula alleghaniensis)*
Link to full species profile: https://rngr.net/publications/tpn/65-1/yellow-birch-guidelines-for-seed-transfer-within-the-northeastern-united-states/

Genetics	Gene flow (pollen): High.[1,2,3] Gene flow seed: High. [4,5]
Insects and Diseases	Most insect and disease problems are associated with mature stands. Bronze birchborer, nectria canker, cider conk, and skeletonizer. Decadent stands may exhibit crown dieback and decline.
Maximum Transfer Distance	No specific transfer distances have been calculated. Managers should be aware of the potential to hybridize with paper birch.[3]

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Sugar Maple (*Acer saccharum*)
Link to full profile: https://rngr.net/publications/tpn/65-2/sugar-maple-guidance-for-seed-transfer-within-the-eastern-united-states/

Genetics	Genetic diversity: high.[1,2,3,4,5] Gene flow (pollen): high. Gene flow (seed): moderate to high. [6,7,8]
Insects and Diseases	Forest tent caterpillar, pear thrips, sugar maple borer, and Asian longhorned beetle. Armillaria, anthracnose, and Eutypella canker.
Maximum Transfer Distance	Seed-transfer distances have not been tested across its range. Based on common garden studies, 100 to 200 mi (161 to 322 km) is the longest recommended seed-transfer distance. [9]

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Red Spruce (*Picea rubens*)

Link to full profile: https://rngr.net/publications/tpn/67-1/red-spruce-guidance-for-seed-transfer-within-the-eastern-united-states/

Genetics	Genetic diversity [1,2]: low compared with other outcrossing conifers; Gene flow[3],4: historically high within regions, though may be reduced due to habitat fragmentation and land use; gene flow between regions appears limited.
Insects and Diseases	Spruce budworm, spruce coneworm, yellowheaded spruce sawfly, eastern dwarf mistletoe, and Eastern spruce gall adelgid.
Maximum Transfer Distance	Intermediate tolerance to seed transfer (200–300 mi [322–483 km]). Transfer to colder climates (more than 1.8 °F [2 °C] colder than the source) often results in cold damage and reduced growth. Transfer into warmer climates (5.4 to 9 °F [3 to 5 °C]) warmer than source) may be tolerable but must be evaluated with consideration to temperature seasonality (warmer winters may benefit red spruce while warmer summers do not) and transpirational demand. [5,6,7,8]

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Black Cherry (*Prunus serotina*)
List to full profile: https://rngr.net/publications/tpn/67-1/black-cherry-guidance-for-seed-transfer-within-the-eastern-united-states/

Genetics	Genetic diversity: high.[1] Gene flow: high.
Insects and Diseases	Eastern tent caterpillar and cherry scallop shell moth are major defoliators. Peachtree borer and peach bark beetle attack stems. Vulnerable to generalist decay fungi. Black knot fungus causes defects.
Maximum Transfer Distance	Relatively sensitive to seed transfer: distances less than 200 mi (322 km) are safe. Use caution with transfers greater than 250 mi (402 km).[2,3] Black cherry has showed strong site by provenance interactions and poor performance of sources that had been moved more than 5 degrees latitude north or south of the planting site (Carter et al. 1983, Genys and Cech 1975).

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Vermont Climate Change Tree Atlas Table: Summaries of the species associated with the region and described in the table on the next pages. Definitions are provided in the Excel file for this region.

https://www.fs.usda.gov/nrs/atlas/combined/resources/summaries/states/Vermont.pdf

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	sq. km	sq. mi	FIA Plots
Area of Region	24,912	9,618.7	826

Species Information

The columns below provide breif summaries of the species associated with the region and described in the table on the next pages. Definitions are provided in the Excel file for this region.

Genus	Species
Ash	3
Hickory	3
Maple	6
Oak	6
Pine	3
Other	32
	53

Abundance	
Abundant	7
Common	13
Rare	33
Absent	38
	91

	Model Reliability	Adaptability
High	22	24
Medium	31	47
Low	34	17
FIA	4	
	91	**88**

Potential Change in Habitat Suitability	Scenario RCP45	Scenario RCP85
Increase	21	22
No Change	11	10
Decrease	17	17
New	32	33
Unknown	10	9
	91	**91**

Capability to Cope or Persist	Scenario RCP45	Scenario RCP85
Very Good	2	2
Good	17	17
Fair	12	14
Poor	9	8
Very Poor	8	6
FIA Only	2	2
Unknown	6	5
	56	**54**

Migration Potential	SHIFT RCP45	SHIFT RCP85
Likely	4	4
Infill	14	13
Migrate	6	11
	24	**28**

Potential Changes in Climate Variables

Temperature (°F)

	Scenario	2009	2039	2069	2099
Annual Average	CCSM45	42.7	44.7	47.2	47.3
	CCSM85	42.7	45.3	47.9	51.3
	GFDL45	42.7	46.1	49.4	50.9
	GFDL85	42.7	46.4	50.8	55.9
	HAD45	42.7	45.9	49.1	50.9
	HAD85	42.7	46.0	50.2	55.9
Growing Season May—Sep	CCSM45	60.7	62.9	64.7	65.2
	CCSM85	60.7	63.1	65.6	69.5
	GFDL45	60.7	64.3	67.8	69.5
	GFDL85	60.7	64.7	69.4	74.8
	HAD45	60.7	63.8	66.5	68.9
	HAD85	60.7	63.5	68.0	74.2
Coldest Month Average	CCSM45	14.4	16.2	18.5	18.7
	CCSM85	14.4	17.5	18.8	21.3
	GFDL45	14.4	17.6	20.1	21.3
	GFDL85	14.4	18.7	21.0	24.0
	HAD45	14.4	17.2	20.3	20.7
	HAD85	14.4	18.5	21.1	24.9
Warmest Month Average	CCSM45	66.7	69.1	70.3	70.5
	CCSM85	66.7	69.6	71.3	73.4
	GFDL45	66.7	69.7	71.8	73.2
	GFDL85	66.7	70.7	73.6	76.5
	HAD45	66.7	70.0	71.5	72.9
	HAD85	66.7	69.7	72.3	76.7

Precipitation (in)

	Scenario	2009	2039	2069	2099
Annual Total	CCSM45	46.1	45.2	43.8	48.5
	CCSM85	46.1	46.2	47.0	48.8
	GFDL45	46.1	50.4	52.7	51.2
	GFDL85	46.1	48.5	51.2	52.9
	HAD45	46.1	49.2	50.9	50.5
	HAD85	46.1	50.4	49.9	53.5
Growing Season May—Sep	CCSM45	21.6	21.5	20.0	21.8
	CCSM85	21.6	21.3	21.8	20.7
	GFDL45	21.6	22.1	21.2	21.3
	GFDL85	21.6	21.8	21.3	20.1
	HAD45	21.6	23.2	22.3	23.2
	HAD85	21.6	22.2	21.8	23.6

NOTE: For the six climate variables, four 30-year periods are used to indicate six potential future trajectories. The period ending in 2009 is based on modeled observations from the PRISM Climate Group and the three future periods were obtained from the NASA NEX-DCP30 dataset. Future climate projections from three models under two emission scenarios show estimates of each climate variable within the region. The three models are CCSM4, GFDL CM3, and HadGEM2-ES and the emission scenarios are the 4.5 and 8.5 RCP. The average value for the region is reported, even though locations within the region may vary substantially based on latitude, elevation, land-use, or other factors.

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Common Name	Scientific Name	Range	MR	%Cell	FIAsum	FIAiv	ChngCl45	ChngCl85	Adap	Abund	Capabil45	Capabil85	SHIFT45	SHIFT85	SSO	N
sugar maple	Acer saccharum	WDH	High	90.3	1914.8	19.9	Sm. dec.	Sm. dec.	High	Abundant	Good	Good			1	1
red maple	Acer rubrum	WDH	High	89.3	1151.2	11.0	Sm. inc.	Sm. inc.	High	Abundant	Very Good	Very Good			1	2
eastern hemlock	Tsuga canadensis	NSH	High	60.7	856.5	12.0	No change	Sm. dec.	Low	Abundant	Fair	Fair			0	3
American beech	Fagus grandifolia	WDH	High	82.9	792.3	9.1	Sm. dec.	Sm. dec.	Medium	Abundant	Fair	Fair			0	4
eastern white pine	Pinus strobus	WDH	High	52.9	697.6	10.6	Sm. inc.	No change	Low	Abundant	Good	Fair			1	5
yellow birch	Betula alleghaniensis	NDL	High	77.4	674.2	8.2	Sm. dec.	Sm. dec.	Medium	Abundant	Fair	Fair			0	6
balsam fir	Abies balsamea	NDH	High	51.8	600.6	9.7	Sm. dec.	Sm. dec.	Low	Abundant	Fair	Fair			0	7
white ash	Fraxinus americana	WDL	Medium	77.3	475.2	5.2	Sm. inc.	Sm. inc.	Low	Common	Fair	Fair			1	8
red spruce	Picea rubens	NDH	High	63.9	434.2	6.2	Sm. dec.	Sm. dec.	Low	Common	Poor	Poor			0	9
paper birch	Betula papyrifera	WDH	High	73.9	424.5	4.8	No change	Sm. dec.	Medium	Common	Fair	Poor			1	10
black cherry	Prunus serotina	WDL	Medium	60	235.8	3.3	Lg. inc.	Lg. inc.	Low	Common	Good	Good			1	11
northern white-cedar	Thuja occidentalis	WSH	High	18.3	228.7	10.5	Sm. dec.	Sm. dec.	Medium	Common	Poor	Poor			0	12
northern red oak	Quercus rubra	WDH	Medium	33.6	213.6	4.9	Lg. inc.	Lg. inc.	High	Common	Very Good	Very Good			1	13
quaking aspen	Populus tremuloides	WDH	High	39.1	189.1	3.7	Sm. inc.	Sm. inc.	Medium	Common	Good	Good			1	14
eastern hophornbeam; ironw	Ostrya virginiana	WSL	Low	46.9	164.0	3.2	No change	No change	High	Common	Good	Good			1	15
sweet birch	Betula lenta	NDH	High	19.6	158.4	5.2	Lg. inc.	Lg. inc.	Low	Common	Good	Good	Infill ++	Infill ++	1	16
American elm	Ulmus americana	WDH	Medium	31.2	112.2	3.2	Sm. inc.	Sm. inc.	Medium	Common	Good	Good			1	17
white spruce	Picea glauca	NSL	Medium	12.5	69.8	4.4	Sm. dec.	No change	Medium	Common	Poor	Fair	Infill +	Infill +	1	18
black ash	Fraxinus nigra	WSH	Medium	15.8	64.4	3.5	Lg. dec.	Lg. dec.	Low	Common	Very Poor	Very Poor			0	19
pin cherry	Prunus pensylvanica	NSL	Low	26.1	55.6	1.9	Lg. dec.	Lg. dec.	Medium	Common	Poor	Poor			0	20
American basswood	Tilia americana	WSL	Medium	16.2	49.0	2.4	Lg. inc.	Lg. inc.	Medium	Rare	Good	Good			1	21
balsam poplar	Populus balsamifera	NSH	Medium	6.8	42.1	5.1	Lg. dec.	Very Lg. dec.	Medium	Rare	Very Poor	Lost			0	22
bitternut hickory	Carya cordiformis	WSL	Low	14.1	41.2	2.8	Sm. inc.	Lg. inc.	High	Rare	Good	Good	Infill ++	Infill ++	1	23
gray birch	Betula populifolia	NSL	Low	17.1	39.9	2.3	Sm. dec.	No change	Medium	Rare	Very Poor	Poor			1	24
bigtooth aspen	Populus grandidentata	NSL	Medium	14.1	37.6	2.2	Lg. inc.	Lg. inc.	Medium	Rare	Good	Good			1	25
Norway spruce	Picea abies	NSH	FIA	3	29.5	8.1	Unknown	Unknown	NA	Rare	NNIS	NNIS			0	26
shagbark hickory	Carya ovata	WSL	Medium	3.7	23.7	4.0	Sm. inc.	Sm. inc.	Medium	Rare	Fair	Fair	Infill +	Infill +	2	27
silver maple	Acer saccharinum	NSH	Low	0.8	23.2	12.3	No change	No change	High	Rare	Fair	Fair	Infill +	Infill +	2	28
green ash	Fraxinus pennsylvanica	WSH	Low	6	23.0	4.7	No change	Sm. inc.	Medium	Rare	Poor	Fair	Infill +	Infill +	2	29
black locust	Robinia pseudoacacia	NDH	Low	2.5	21.5	11.2	Lg. inc.	Lg. inc.	Medium	Rare	Good	Good	Infill ++	Infill ++	2	30
boxelder	Acer negundo	WSH	Low	0.9	19.3	8.4	No change	No change	High	Rare	Fair	Fair	Infill +	Infill +	2	31
white oak	Quercus alba	WDH	Medium	4.7	17.7	1.8	Lg. inc.	Lg. inc.	High	Rare	Good	Good	Infill ++	Infill ++	2	32
red pine	Pinus resinosa	NSH	Medium	1.7	17.2	3.2	No change	No change	Low	Rare	Very Poor	Very Poor			2	33
butternut	Juglans cinerea	NSLX	FIA	4	15.2	3.4	Unknown	Unknown	Low	Rare	FIA Only	FIA Only			0	34
eastern redcedar	Juniperus virginiana	WDH	Medium	1.7	14.4	6.2	Lg. inc.	Lg. inc.	Medium	Rare	Good	Good			2	35
slippery elm	Ulmus rubra	WSL	Low	0.2	13.9	4.3	No change	No change	Medium	Rare	Poor	Poor	Infill +	Infill +	2	36
serviceberry	Amelanchier spp.	NSL	Low	15.7	12.3	0.8	Sm. inc.	Sm. inc.	Medium	Rare	Fair	Fair			1	37
tamarack (native)	Larix laricina	NSH	High	4.9	11.4	1.8	Sm. dec.	Sm. dec.	Low	Rare	Very Poor	Very Poor			2	38
eastern cottonwood	Populus deltoides	NSH	Low	0.9	11.1	8.0	No change	Sm. inc.	Medium	Rare	Poor	Fair	Infill +	Infill +	2	39
Scots pine	Pinus sylvestris	NSH	FIA	1.6	9.0	5.6	Unknown	Unknown	NA	Rare	NNIS	NNIS			0	40
American hornbeam; muscle	Carpinus caroliniana	WSL	Low	6.3	8.5	1.3	No change	No change	Medium	Rare	Poor	Poor	Infill +	Infill +	1	41
bur oak	Quercus macrocarpa	NDH	Medium	2.8	8.1	5.3	No change	No change	High	Rare	Fair	Fair	Infill +	Infill +	2	42
black walnut	Juglans nigra	WDH	Low	0.2	6.7	2.1	Sm. inc.	Lg. inc.	Medium	Rare	Fair	Good	Infill +		2	43
mountain maple	Acer spicatum	NSL	Low	9.6	6.6	0.7	Lg. dec.	Lg. dec.	High	Rare	Poor	Poor			1	44
American mountain-ash	Sorbus americana	NSL	Low	6.4	5.2	0.8	Lg. dec.	Lg. dec.	Low	Rare	Very Poor	Very Poor			0	45
chestnut oak	Quercus prinus	NDH	High	2.1	4.2	1.4	Lg. inc.	Lg. inc.	High	Rare	Good	Good			2	46
black spruce	Picea mariana	NSH	High	0.4	2.0	5.0	Very Lg. dec.	Very Lg. dec.	Medium	Rare	Lost	Lost			0	47

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Common Name	Scientific Name	Range	MR	%Cell	FIAsum	FIAiv	ChngCl45	ChngCl85	Adap	Abund	Capabil45	Capabil85	SHIFT45	SHIFT85	SSO	N
chokecherry	Prunus virginiana	NSLX	FIA	2.2	1.7	0.7	Unknown	Unknown	Medium	Rare	FIA Only	FIA Only			0	48
black oak	Quercus velutina	WDH	High	0.4	1.7	0.6	Lg. inc.	Lg. inc.	Medium	Rare	Good	Good			2	49
striped maple	Acer pensylvanicum	NSL	Medium	15.4	0.4	0.7	Sm. dec.	Sm. dec.	Medium	Rare	Very Poor	Very Poor			0	50
Atlantic white-cedar	Chamaecyparis thyoides	NSH	Low	0.4	0.3	0.7	Sm. dec.	Lg. dec.	Low	Rare	Very Poor	Very Poor			0	51
mockernut hickory	Carya alba	WDL	Medium	0.3	0.2	0.4	Lg. inc.	Lg. inc.	High	Rare	Good	Good			2	52
swamp white oak	Quercus bicolor	NSL	Low	1.6	0.0	0.3	Lg. inc.	Lg. inc.	Medium	Rare	Good	Good			2	53
pitch pine	Pinus rigida	NSH	High	0	0	0	New Habitat	New Habitat	Medium	Absent	New Habitat	New Habitat	Likely +	Likely +	3	54
Virginia pine	Pinus virginiana	NDH	High	0	0	0	New Habitat	New Habitat	Medium	Absent	New Habitat	New Habitat		Migrate +	3	55
bald cypress	Taxodium distichum	NSH	Medium	0	0	0	New Habitat	New Habitat	Medium	Absent	New Habitat	New Habitat			0	56
pawpaw	Asimina triloba	NSL	Low	0	0	0	New Habitat	New Habitat	Medium	Absent	New Habitat	New Habitat			3	57
cittamwood/gum bumelia	Sideroxylon lanuginosum ssp.	NSL	Low	0	0	0	Unknown	New Habitat	High	Absent	Unknown	New Habitat			0	58
water hickory	Carya aquatica	NSL	Medium	0	0	0	New Habitat	New Habitat	Medium	Absent	New Habitat	New Habitat			0	59
pignut hickory	Carya glabra	WDL	Medium	0	0	0	New Habitat	New Habitat	Medium	Absent	New Habitat	New Habitat	Likely +	Likely +	3	60
pecan	Carya illinoinensis	NSH	Low	0	0	0	New Habitat	New Habitat	Low	Absent	New Habitat	New Habitat			0	61
shellbark hickory	Carya laciniosa	NSL	Low	0	0	0	Unknown	Unknown	Medium	Absent	Unknown	Unknown			0	62
black hickory	Carya texana	NDL	High	0	0	0	New Habitat	New Habitat	Medium	Absent	New Habitat	New Habitat			0	63
sugarberry	Celtis laevigata	NDH	Medium	0	0	0	New Habitat	New Habitat	Medium	Absent	New Habitat	New Habitat			0	64
hackberry	Celtis occidentalis	WDH	Medium	0	0	0	New Habitat	New Habitat	High	Absent	New Habitat	New Habitat	Migrate +	Migrate +	3	65
eastern redbud	Cercis canadensis	NSL	Low	0	0	0	New Habitat	New Habitat	Medium	Absent	New Habitat	New Habitat			0	66
flowering dogwood	Cornus florida	WDL	Medium	0	0	0	New Habitat	New Habitat	Medium	Absent	New Habitat	New Habitat		Migrate +	3	67
common persimmon	Diospyros virginiana	NSL	Low	0	0	0	New Habitat	New Habitat	High	Absent	New Habitat	New Habitat			3	68
honeylocust	Gleditsia triacanthos	NSH	Low	0	0	0	New Habitat	New Habitat	High	Absent	New Habitat	New Habitat			3	69
sweetgum	Liquidambar styraciflua	WDH	High	0	0	0	New Habitat	New Habitat	Medium	Absent	New Habitat	New Habitat		Migrate ++	3	70
yellow-poplar	Liriodendron tulipifera	WDH	High	0	0	0	New Habitat	New Habitat	High	Absent	New Habitat	New Habitat	Migrate +	Migrate ++	3	71
Osage-orange	Maclura pomifera	NDH	Medium	0	0	0	New Habitat	New Habitat	High	Absent	New Habitat	New Habitat		Migrate +	3	72
southern magnolia	Magnolia grandiflora	NSL	Low	0	0	0	Unknown	Unknown	Medium	Absent	Unknown	Unknown			0	73
bigleaf magnolia	Magnolia macrophylla	NSL	Low	0	0	0	Unknown	Unknown	Medium	Absent	Unknown	Unknown			0	74
mountain or Fraser magnolia	Magnolia fraseri	NSL	Low	0	0	0	Unknown	New Habitat	NA	Absent	Unknown	New Habitat			0	75
blackgum	Nyssa sylvatica	WDL	Medium	0	0	0	New Habitat	New Habitat	High	Absent	New Habitat	New Habitat	Migrate +	Migrate +	3	76
redbay	Persea borbonia	NSL	Low	0	0	0	Unknown	Unknown	High	Absent	Unknown	Unknown			0	77
sycamore	Platanus occidentalis	NSL	Low	0	0	0	New Habitat	New Habitat	Medium	Absent	New Habitat	New Habitat	Migrate +	Migrate +	3	78
scarlet oak	Quercus coccinea	WDL	Medium	0	0	0	New Habitat	New Habitat	Medium	Absent	New Habitat	New Habitat	Likely +	Likely +	3	79
northern pin oak	Quercus ellipsoidalis	NSH	Medium	0	0	0	New Habitat	Unknown	High	Absent	New Habitat	Unknown			3	80
shingle oak	Quercus imbricaria	NDH	Medium	0	0	0	New Habitat	New Habitat	Medium	Absent	New Habitat	New Habitat			3	81
overcup oak	Quercus lyrata	NSL	Medium	0	0	0	New Habitat	New Habitat	Low	Absent	New Habitat	New Habitat			0	82
blackjack oak	Quercus marilandica	NSL	Medium	0	0	0	New Habitat	New Habitat	High	Absent	New Habitat	New Habitat			3	83
chinkapin oak	Quercus muehlenbergii	NSL	Medium	0	0	0	New Habitat	New Habitat	Medium	Absent	New Habitat	New Habitat		Migrate +	3	84
pin oak	Quercus palustris	NSH	Low	0	0	0	New Habitat	New Habitat	Low	Absent	New Habitat	New Habitat	Migrate +	Migrate +	3	85
willow oak	Quercus phellos	NSL	Low	0	0	0	New Habitat	New Habitat	Medium	Absent	New Habitat	New Habitat			3	86
Shumard oak	Quercus shumardii	NSL	Low	0	0	0	New Habitat	New Habitat	High	Absent	New Habitat	New Habitat			0	87
post oak	Quercus stellata	WDH	High	0	0	0	New Habitat	New Habitat	High	Absent	New Habitat	New Habitat			3	88
black willow	Salix nigra	NSH	Low	0	0	0	New Habitat	New Habitat	Low	Absent	New Habitat	New Habitat	Likely +	Likely +	3	89
sassafras	Sassafras albidum	WSL	Low	0	0	0	New Habitat	New Habitat	Medium	Absent	New Habitat	New Habitat	Migrate +	Migrate +	3	90
winged elm	Ulmus alata	WDL	Medium	0	0	0	New Habitat	New Habitat	Medium	Absent	New Habitat	New Habitat			0	91

Appendix E. How-to Guides for Planting

The following is a descriptive short list of how-to planting resources. When implementing any planting project, managers should review the General Planting Guidelines and the Guidelines for Planting Project Types as a first step.

1. **2022 VTrans Riparian Planting Toolkit**: This document was developed based on existing riparian buffer guidelines from the Vermont Agency of Natural Resources, Vermont Natural Resources Conservation Service, Virginia Department of Environmental Conservation, among other regional resources. The recommendations in these resources were combined to apply to common transportation related projects within the Vermont Agency of Transportation. Website: https://vtrans.vermont.gov/sites/aot/files/highway/documents/environmental/2022%20VTrans%20Riparian%20Planting%20Toolkit.pdf.

2. **Forest Landowner's Guide to Tree Planting Success**: The Forest Landowner's Guide to Tree Planting Success provides practical steps for achieving successful tree planting on forested lands. It covers planning, site preparation, species selection, planting techniques, and post-planting care. The guide emphasizes the importance of proper timing, protecting young trees from wildlife, and ongoing maintenance to ensure long-term survival and forest regeneration. The resource is designed to help landowners restore forests and improve land health. Some tree species on their planting list do not occur or are rare in Vermont, so be sure to double check before making a final plant list with this resource. Website: https://extension.psu.edu/forest-landowners-guide-to-tree-planting-success.

3. **2022 Northwest VT Riparian Planting Guide:** The "Northwest VT Riparian Planting Guide" provides comprehensive information on riparian planting projects in northwestern Vermont. It outlines available planting programs and funding sources, including opportunities for collaboration among various partner organizations such as Natural Resources Conservation Districts and local and federal agencies. The guide offers detailed guidance on selecting and designing planting projects, emphasizing considerations like landowner outreach, species selection, and site preparation. It also addresses the implementation and maintenance of planting projects, highlighting the importance of post-planting care and monitoring. Finally, the guide discusses current challenges and opportunities, advocating for enhanced collaboration and better communication to ensure project success. Website: https://www.uvm.edu/seagrant/sites/default/files/uploads/Northwest%20VT%20Riparian%20Planting%20Guide%20FINAL.pdf.

4. **2016 Planting Guidance for the Revegetation of Riparian Areas in Vermont:** A guidance document for planting in riparian areas developed by the Vermont Fish and Wildlife Department along with other partners. Website: https://anr.vermont.gov/sites/anr/files/documents/Planting-Guidance-for-Riparian-Areas-VT-2016.pdf.

5. **An Introduction to using native plants in restoration projects:** This document provides guidance on using native plants in restoration projects. It discusses planning considerations such

as establishing timelines, determining project targets by defining problems and setting goals/objectives, and evaluating site characteristics. It also covers choosing appropriate plant species, understanding genetics, reintroduction methods, seed and plant sources, specifications for obtaining materials, site preparation, planting, and ongoing site maintenance (Vlachoy83g, 2024). Website: https://www.fs.usda.gov/wildflowers/Native_Plant_Materials/documents/intronatplant.pdf.

6. **Wild Seed Project Website:** Wild Seed Project raises awareness about the critical role of native plants and offers resources to help restore biodiversity in local communities. By providing tools and guidance, the organization empowers community members, public officials, municipalities, and landowners—including farmers and land trusts—to collaboratively restore landscapes with native plants. These efforts enhance wildlife habitat, support biodiversity, and strengthen climate resilience. Website: https://wildseedproject.net/.

7. **Basic Instructions for Native Plant Landscaping Projects:** U.S. Forest Service website resource. Website: https://www.fs.usda.gov/wildflowers/Native_Plant_Materials/Native_Gardening/instructions.shtml.

8. **Vermont Urban & Community Forestry Program Website:** The resources on this website inform site assessments for tree planting and guide site designs that ensure space and resources for urban and community trees. These resources were developed for urban areas. When utilizing plant lists from this resource, choose native local ecotypes as a first option on state lands. Website: https://vtcommunityforestry.org/tree-care/tree-selection-planting.

Appendix F. Nurseries and Plant Sources

The following section is a descriptive list of in-state and regional suppliers that offer competitively priced native species for ANR planting projects. This list is subdivided into a list of currently active suppliers and emerging suppliers. Unless stated otherwise, suppliers within this list also offer some Vermont ecotypes. Nonetheless, only one nursery (The Farm Upstream) in this list is currently known to exclusively supply Vermont ecotypes. Consequently, planters should verify the origins of plants with these suppliers prior to purchase and prioritize the purchase of Vermont ecotypes wherever possible. Additionally, while the listed suppliers currently offer most species listed in our planting lists in Appendix D, it is important to note that some ecologically important plants that are listed, namely upland shrubs (ex. hobblebush, alternate-leaved dogwood) are currently not commonly available and are relatively expensive items. This problem will likely lessen as the crowdsourced collection of ecotypic seed increases and as emerging suppliers develop stable inventories in the near future. In the meantime, care must be taken to ensure that plantings that supplement unavailable species are also ecologically appropriate and, ideally, Vermont ecotypes.

Active Suppliers

Annual Vermont Natural Resources Conservation District Plant Sales
(https://www.vacd.org/contact-nrcds/)

Each spring, regional and county Natural Resource Conservation Districts organize plant sales across Vermont. Orders are due at various points during winter. These events are affordable opportunities to secure a diversity of native species, largely trees and shrubs. While some Vermont ecotypes may be available for sale in certain districts, it is important to note that these sales often involve the merging of several growers' inventories from across New England and as far away as Michigan. Visit their webpage to contact districts to learn the timing and inventory of the next plant sale.

Ausable Conservation Nursery at Uihlein Farm, Wilmington, NY
(https://www.ausableriver.org/programs/ausable-conservation-nursery)

Email: kiana@ausableriver.org

This nursery currently specializes in wetland trees and shrubs but is in the process of diversifying their inventory to include upland trees and shrubs. Additionally, it is transitioning to an inventory that is predominantly sourced from the Adirondacks. Consequently, while this nursery may offer some Vermont ecotypes, it will likely become a much more substantial resource for Vermont ecotypes in the near future.

Blue Stem Natives, Norwell, MA
(https://www.bluestemnatives.com/)

Email: info@BlueStemNatives.com Phone: (781) 738-4869

This is a small retail and wholesale nursery that sells a diverse and changing range of upland trees, shrubs, and herbaceous plants, several of which are not currently sold by other regional nurseries (ex.

hobblebush). The nursery also sells several wetland plants. Some Vermont ecotypic plantings may be available depending on current inventory.

Central Appalachian Spruce Restoration Initiative (CASRI)
(https://restoreredspruce.org/)

Fore red spruce only, a partnership of diverse interests with a common goal of restoring historic red spruce-northern hardwood ecosystems across the high elevation landscapes of Central Appalachia. It is comprised of private, state, federal, and non-governmental organizations which recognize the importance of this ecosystem for its ecological, aesthetic, recreational, economic, and cultural values

Champlain Valley Native Plant Restoration Nursery, Poultney, VT.
(https://www.pmnrcd.org/champlain-valley-native-plant-restoration-nursery/)

Email: sadie@pmnrcd.org Phone: (802) 287-6606

This nursery carries a great portion of the tree and shrub species that are abundant in Vermont's upland and wetland communities, alongside several native herbaceous species. Many of the plantings sold by this nursery are Vermont ecotypes and are collected locally.

Colonel William F. Fox Memorial Saratoga Tree Nursery, Saratoga Springs, NY.
(https://dec.ny.gov/nature/forests-trees/saratoga-tree-nursery)

Email: nysnursery@dec.ny.gov Phone: (518) 581-1439

This is the New York DEC nursery. All of the nursery's stock is grown from seed collected within New York, and consequently many of the plantings offered are ecotypic to Vermont. The nursery sells a variety of upland and wetland tree and shrub species. High quantities of seedlings can be purchased affordably during the nursery's "Spring Seedling Sale", which begins each January.

Ernst Seeds, Meadville, PA
(https://www.ernstseed.com/)

Email: sales@ernstseed.com Phone: (800) 873-3321

This nursery offers a very high diversity of herbaceous plants and grasses, alongside some trees and shrubs, at affordable prices. However, the majority of the plants sold at Ernst are not ecotypic to Vermont. Nonetheless, a substantial portion of the plants sold at Ernst at a given time may be Vermont and New England ecotypes as Ernst sources plants from across the Northeast.

Essex County Natural Resource Conservation District Nursery, Ferdinand, VT

Email: smayne.essexnrcd@gmail.com

This nursery grows native trees, largely grown from local Vermont seed, for restoration and agroforestry projects in Vermont. It closes each year in the early summer. It is an invaluable local resource for Vermont ecotypes.

Intervale Conservation Nursery, Burlington, VT
(https://www.intervale.org/intervale-conservation-nursery)

Email: benr@intervale.org Phone: (802) 660-0440

Intervale specializes in wetland and lowland trees and shrubs, while also carrying a changing variety of upland trees and shrubs and herbaceous plants. Intervale is actively increasing their inventory of local ecotypes, but currently still sells non-ecotypic plants imported from locations as far away as Michigan. Contact the attached email for an updated availability list and to learn the ecotypic status of current inventory items.

Miller Hill Farm, Sudbury, VT
(https://millerhillfarmvt.com/)

Email: mhfarm@shoreham.net Phone: (802) 623-7373

This small nursery carries several important native wetland and upland trees, including some species (ex. chokecherry) that may be difficult to source from other suppliers. This nursery also supplies native wetland shrubs, and a variety of perennial plants. Many of the plants sold here are Vermont ecotypes and are sourced locally.

Nasami Farm, Whately, MA
(https://www.nativeplanttrust.org/for-your-garden/nasami-farm/)

Email: nasaminatives@NativePlantTrust.org Phone: (413) 241-5614

This nursery sells an almost unparalleled variety of native trees, shrubs, and herbaceous plants, the vast majority of which originate from seed collected within New England. Their inventory commonly includes Vermont ecotypes, which can be easily identified in the Farm's inventory as staff record the origin of each seed lineage wherever possible.

New England Wetland Plants, South Hadley, MA
(https://newp.com/)

Email: info@newp.com Phone: (413) 548-8000

NEWP sells a decent range of upland and wetland trees, and several important wetland shrubs. Notably, this nursery also carries many native herbaceous and fern species at relatively affordable prices. Most of the plants that NEWP carries are New England ecotypes. However, some seed mixes sold by NEWP contain nonnative species, and regionally native species that may be uncommon in Vermont.

New Hampshire State Forest Nursery, Boscawen, NH
(https://www.nh.gov/nhnursery/)

Email: Concord.Nursery@dncr.nh.gov Phone: (603) 796-2323

This nursery sells a limited range of native species, mostly upland and montane tree species. They also sell several shrub species, largely native wetland species. That said, this nursery is not known to supply Vermont ecotypes. Plants are exclusively sold as bare root seedlings and can be purchased in bulk affordably. This nursery is open seasonally from December through May.

The Farm Upstream, Jericho, VT
(https://www.thefarmupstream.com/)

Email: thefarmupstream@gmail.com

This is a small fledgling nursery offering native shrubs and vines. While limited, their inventory is exclusively Vermont ecotypes, and their pricing is quite competitive. With sufficient notice, this nursery can offer wholesale pricing and additional native species.

Vermont Wetland Plant Supply, Orwell, VT
(https://www.vermontwetlandplants.com/)

Email: dredondo@vermontwetlandplants.com Phone: (802) 989-4629

This nursery carries facultative wetland and obligate wetland trees and shrubs, alongside a diversity of fern species. VWPS also supplies native herbaceous plant seed mixes suited to upland and wetland environments. The vast majority of plants that VWPS sells are Vermont ecotypes, and plants that are not Vermont ecotypes are sourced regionally and labelled accordingly. That said, some seed mixes contain regionally native species that have been introduced to Vermont.

Emerging Suppliers

While they are not a current source of native plantings, the following suppliers should be monitored and contacted in seasons to come. Contacts for each supplier are included below.

Missisquoi River Basin Association Native Plant Nursery, Berkshire, VT.
Contact: Lindsey Wight (lindsey@mrbavt.com), Ellen Fox (ellen@mrbavt.com)

Verterra LLC, Hinesburg, VT.
Contact: David Berg (daveski85@gmail.com)

Appendix G. Climate Change Adaptation Tools & Resources

1. **Adaptation Management Strategies for Northern Forest Ecosystems in New England and New York:** The resource pages in this series summarize information from climate change vulnerability assessments created for three major forest types in New England and northern New York. Adaptation actions to respond to specific climate risks are also highlighted.
   a) **Adaptation Actions for Northern Hardwood Forests in New England and New York:** https://www.climatehubs.usda.gov/hubs/northern-forests/topic/adaptation-actions-northern-hardwood-forests-new-england-and-new-york
   b) **Adaptation Actions for Mixed Wood Forests in New England and New York**: https://www.climatehubs.usda.gov/hubs/northern-forests/topic/adaptation-actions-mixedwood-forests-new-england-and-new-york
   c) **Adaptation Actions for Spruce-Fir Forests in New England and New York**: https://www.climatehubs.usda.gov/hubs/northern-forests/topic/adaptation-actions-spruce-fir-forests-new-england-and-new-york

2. **Forest Adaptation Resources: Climate Change Tools and Approaches for Land Managers, 2nd edition** (USDA Northern Research Station, 2016): The second edition of the Forest Adaptation Resources provides tools to help forest managers integrate climate change considerations into their practices. Developed through the Climate Change Response Framework, this resource reflects input from numerous contributors and users of the first edition. It consists of six chapters: (1) an overview of the Climate Change Response Framework, (2) guidance for vulnerability assessments, (3) a menu of adaptation strategies for forests in the Northeast and upper Midwest, (4) a second menu focused on urban forests, (5) a workbook with step-by-step instructions for developing climate adaptation tactics, and (6) real-world examples of adaptation efforts. These resources are designed to support decision-making across organizations with diverse forest management goals.
   a) https://www.fs.usda.gov/research/treesearch/52760

3. **Northern Institute of Applied Climate Science (NIACS) Adaptation Workbook** (Climate Change Response Framework, 2024): The Adaptation Workbook is a tool for natural resource professionals to consider the potential effects of climate change on forests and identify associated actions that can help reduce risk and increase the ability to cope with changing conditions. It provides a flexible process that accommodates a wide variety of geographic locations, scales, ecosystems, land uses, management goals, and ownership types.
   a) https://forestadaptation.org/adapt/adaptation-workbook

4. **Increasing Forest Resiliency** (Catanzaro, D'Amato, & Silver Huff, 2016): This publication discusses strategies to make northeastern forests more resilient to climate change. It highlights the importance of maintaining diverse and structurally complex forests, adaptive management practices, and monitoring changes in forest health. The guide provides actionable steps for landowners and managers to enhance forest resilience, including selecting climate-adapted species, controlling invasive species, and promoting forest regeneration.
   a) https://masswoods.org/sites/masswoods.net/files/Forest-Resiliency.pdf

5. **Climate Change Tree Atlas** (United States Forest Service, 2024)**:** The Climate Change Tree Atlas is a tool designed to project the potential impacts of climate change on the habitats of various tree species in the eastern United States. It utilizes climate models to predict changes in tree distribution, helping researchers and forest managers understand which species might thrive or decline under different climate scenarios. The atlas includes detailed maps and data on over 100 tree species, considering factors like temperature, precipitation, and soil conditions. It aims to inform conservation and adaptation strategies to preserve forest ecosystems in a changing climate.
   a) https://www.fs.usda.gov/nrs/atlas/tree/
   b) Summary Tables for Vermont: https://www.fs.usda.gov/nrs/atlas/combined/resources/summaries/states/Vermont.pdf

6. **Climate Change Response Framework** (Climate Change Response Framework, 2024)**:** The Adaptation Demonstration Projects webpage showcases real-world examples of how land managers are incorporating climate change into their planning and activities. These projects, supported by the Climate Change Response Framework, test innovative ideas and actions to address changing environmental conditions. The page highlights a variety of demonstration projects, each illustrating different adaptation strategies that also meet broader natural resource management goals.
   a) https://forestadaptation.org/adapt/demonstration-projects

7. **Creating and Maintaining Resilient Forests in Vermont: Adapting Forests to Climate Change** (Vermont Dept. of Forests, Parks and Recreation, 2015): This document aims to equip land managers with a comprehensive range of forest adaptation strategies. Recognizing the critical link between statewide policy and forest management, it includes several policy-level strategies along with local and regional solutions to address existing forest management challenges, such as invasive plant species, non-native insect pests, and the conservation of connected forest tracts. This document helps to ensure successful outcomes, integrating climate change considerations into broader management efforts.
   a) https://fpr.vermont.gov/sites/fpr/files/Forest_and_Forestry/The_Forest_Ecosystem/Library/Climate change report_final_v6-18-15a.pdf

Appendix H. Natural Community and Rare Species Ranking and Guidance

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

Links to Ranking and RTE Species Lists

- Vermont Natural Community Ranking Specifications: https://anr.vermont.gov/sites/anr/files/documents/Vermont-Natural-Community-Ranking-Specifications.pdf
- Vermont Endangered and Threatened Species lists and designations: https://vtfishandwildlife.com/learn-more/fish-wildlife-library/wildlife-information/library-endangered-threatened-and-rare-animals-and-plants-lists

Natural Community and Rare Species Ranking and Guidance

The following information provides guidance to assess ecological risk based on natural community ranking and was included in the 2017 Assisted Migration Guidelines (Popp, Zaino, Patch, Thornton, & Wilmot, 2017).

S1 or S2 Natural communities

1. Maintain these communities as self-adapting. Maximize biodiversity and physical landscape diversity, enduring features, and movement corridors as adaptation actions. This is only recommended for assisted migration under special circumstances (e.g., Pine Oak Heath Sandplain Forest)
2. Identify refugia for species and manage to maintain populations.

S3 Natural Communities

1. Priority is to manage these species and natural communities as self-adapting systems.
2. Assisted population migration may be utilized with common (S4 or S5) species found within natural community associations to maintain current species assemblages, enhance functional redundancy

and diversity, and/or to increase abundance of species predicted as climate-adapted to planting location.

3. Assisted population migration of species not within the current natural community associations may be considered on a case-by-case basis, such as where declines are anticipated due to climate change or pest and pathogen damage (e.g. emerald ash borer, beech leaf disease) to maintain current species assemblages, enhance functional redundancy and diversity, and/or to increase species predicted as climate-adapted to planting location.
4. Maximize biodiversity and physical landscape diversity, enduring features, and movement corridors as adaptation actions (see #1 under Climate Adaptation).
5. Leave some natural community examples unaltered as control sites.

S4 and S5 Natural Communities

1. When they occur within well-connected forest blocks or mature forests with sufficient regeneration and more resilient to future climate conditions and invasive pests and pathogens—features expected to have high resilience—S4 and S5 natural communities should be allowed to self-adapt.
2. For all other S4 and S5 natural communities, assisted population migration and assisted range expansion strategies will be considered according to each parcel to maintain current species assemblages, enhance functional redundancy and diversity, and/or to increase species predicted as climate-adapted to planting location.
3. Assisted Species Migration, moving seed sources or populations to a location far outside the historical species range, is not recommended.
4. Maximize biodiversity and physical landscape diversity, enduring features, and movement corridors as adaptation actions (see #1 under Climate Adaptation).
5. Leave some natural community examples unaltered as reference sites.