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Effective Establishment of Native Plant Communities Along New England Roadsides

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Effective Establishment of Native Plant Communities Along New England Roadsides

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Along New England Roadsides

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ABSTRACT

The New England Transportation Consortium (NETC) commissioned research to find the most affordable, reliable, and expeditious methods for establishing native plant communities along New England roadsides and document these findings in a manual that would guide state Departments of Transportation (DOTs) efforts to transform their roadside revegetation management practices. These installations would replace large portions of the introduced cool-season turf grasses commonly used along highways, which require greater resource inputs and frequent mowing. State DOTs hope that, by transitioning to these more sustainable management practices, they can save on fuel costs, decrease machinery emissions, increase pollinator populations, adapt to changing climates, reduce erosion, and improve storm water soil infiltration. The methods by which we collected information to compose the manual included: literature review of peer-reviewed and technical material related to federal and state DOT roadside and right-of-way revegetation; interviews with over 130 practitioners, scientists, specialists, business owners, and academics in the fields of ecological restoration, native seed production, pollinator habitats and health, ecosystem services, and right-of-way vegetation management; and establishment of demonstration plots along U.S. Route 6 in Tolland and Windham Counties in Connecticut. Each plot received site assessments to determine which establishment approaches would best suit each site's microclimate. Establishment techniques included the use of no-till drills, hydroseeding, sawdust as a seed medium, broadcast seeding, and clay seed balls. In the course of this research, it was discovered that extensive populations of native grasses and sedges currently exist along New England roadsides. Techniques were developed for augmenting these native communities that involved properly timed herbicide applications and decreased mowing regimens. A sizable portion of the interview process

involved conducting focus groups with managers from New England DOTs to determine the barriers that might impede successful transitioning from current roadside revegetation practices. These focus groups revealed that successful implementation required buy-in from upper management, cost-benefit analyses that demonstrate that these new practices save money, training programs, and further experimental trials from which agencies can gain experience conducting these new techniques and gather further data about the effectiveness of each technique.

I. INTRODUCTION

This master thesis consists of chapters written for inclusion in a manual written to help New England Departments of Transportation (DOTs) transition from their current practice of revegetating roadsides using introduced cool-season turf grasses to new protocols for revegetating roadsides using native plant species.

The National Highway System consists of 163,000 miles of roads bordered by 3.4 million acres of unpaved land along right-of-ways in the contiguous United States (Ament et al., 2014). These extensive areas provide important ecosystem services, such as runoff reduction, carbon sequestration, improved air quality, and aesthetics. Roadsides represent one of the most extensive networks of linear habitats on earth, which act as corridors for species distribution and by connecting fragmented existing landscape patches. This land supports a diversity of wildlife by providing shelter, food and breeding opportunities for many species including presently threatened pollinators (Hopwood et al., 2016).

Introduced cool-season turf grasses have long served DOTs well in so far as they provide easily-established vegetative cover, quick erosion control, and respond well to repeated mowing. However, recent policy changes require the establishment of native plants along roadsides (Clinton, 1994, 1999). Native plant communities provide long-term defense against invasive and noxious weeds while reducing maintenance costs associated with managing weedy vegetation. Many native grasses, especially warm-season species, have deeper, more extensive root systems and longer life-spans than non-native cool-season turf grasses. They improve long-term slope stability and increase regional biodiversity. Native species have evolved with local climates and soil conditions and generally require less maintenance after establishment.

However, one of the most significant benefits native plant communities provide DOTs is that they require less frequent mowing. Not only does this save money usually spent on fuel and machine maintenance, but it reduces the amount of emissions discharged by mowing equipment. While reduced mowing has obvious economic and environmental benefits, it removes a practice that simplified roadside management. The morphological structure of cool-season turf grasses, with their short-tillers, allows for frequent mowing at low heights. Native warm-season grasses and perennial forbs, on the other hand, would suffer from such frequent mowing, especially during their late-spring to early fall growing season (Smith, 2010).

Despite their long-term ecological and economic benefits, native plant communities require more intensive establishment protocols than do introduced cool-season turf grasses. Unlike introduced cool-season turf grasses, which can be seeded and established within one growing season, native warm-season grasses and forbs germinate slowly. A community of native herbaceous plants can take three to five years to fully establish.

The biggest challenge when establishing native plant communities comes in the form of competition from non-native vegetation, whether from introduced cool-season turf grasses that DOTs have established intentionally or weedy and invasive species that have infiltrated roadsides inadvertently. Undesirable species compete with native plants for resources, including light, soil space, nutrients, and water. Since cool-season grasses start to grow at temperatures lower than those required for warm-season grasses, cool-season grasses have a head start of several weeks to compete for available resources (Smith, 2010). In addition, weed species commonly found along roadsides readily adapt to ruderal environments – disturbed habitats where soil or natural vegetative cover frequently gets damaged, usually as a result of vehicular intrusions. In fact, disturbances give banks of weed seeds and propagules the resources they need

– especially in the form of light – to germinate and outcompete non-weedy species (Zimdahl, 2007). Although weedy and invasive plants can outcompete native species during the establishment process, once native plant communities have established they initiate and accelerate the process of natural ecological succession and, as a result, will eventually outcompete weedy and invasive species better than non-native cool-season turf species can.

However, the transition to biodiverse native plant community establishment requires more complicated management practices compared to the relatively simple, linear process of establishing more monocultural cool-season turf grass. Native plant community establishment involves far more uncertainty since the growth and establishment patterns of native plant species vary far more than do those of cool-season turf grasses. Such factors as the site's microclimate, soil texture, hydrology, topography, and light all influence which species will thrive. The native plant community that will successfully establish on a dry, southern facing slope in Connecticut will vary greatly from the one that will flourish on a flat, frequently flooded roadside in central Maine. As a consequence, the approach to roadside vegetation establishment must incorporate this degree of variability and uncertainty.

Despite the voluminous amount of literature that exists on the subject of native plant community establishment, no one piece of research can provide a precise roadmap for how to effectively establish roadside native plant communities. Even stretches of roadside that run concurrent with one another can have physical and ecological features that will result in plant communities composed of wholly different ranges of grass and forb species. In addition, the fact that the practice of roadside native plant establishment is new to New England means that the knowledge-base for this region has only started to develop. Given the unique ecological conditions of the region, the intent of the manual from which the contents of this thesis are

derived is to provide New England state DOTs specific guidance developed from information derived from a combination of literature reviews, interviews with experts and practitioners, and field experiences obtained during the establishment of the regional demonstration plots. These guidelines for the establishment of native species on roadsides in New England will support transportation goals for safety and infrastructure reinforcement while providing economic, ecological and aesthetic advantages.

II. Site Assessment and Inventory

One of the main goals in transitioning roadsides to native plant communities is to create sustainable landscapes that require minimal long-term maintenance. Achieving such sustainability requires matching the cultural requirements of the plantings to specific site conditions. Since roadside conditions can vary tremendously, no singular plant palette or establishment method exists that can accommodate every roadside. Determining which plants will persist and which planting method will succeed requires thorough site assessment.

The Site Inventory and Assessment method presented in this chapter includes analysis of the following categories:

2.1 Protected Areas Surrounding Site

2.2 Roadside Limitations

2.3 Roadside Typography

2.4 Soil Conditions

2.5 Existing Vegetation

A blank *Site Inventory and Assessment Checklist* located can be copied for collection of data in the field. It will help guide managers through site inventory and assessment and help with planning, selecting site appropriate seed mixes and establishment methods, and developing maintenance strategies. Each section of the checklist explains the purpose for collecting each set of data and how that data will help with the planning process.

2.1 Site Inventory and Assessment Checklist

Site Name ____

Persons Conducting Inventory:____

____

Site Location:

EPA Ecoregion (See Appendix A on p. 93 for map):______________________________

Cold hardiness zone (See Appendix B on pp.94 — 98 for state maps)

Zone 3___ **Zone 4**____ **Zone 5** ____ **Zone 6**____ **Zone 7**____

Route Name or #:____

Route Mile Points :_______________________

Town:____

GPS Coordinates (See Appendix C on p. 99 for iPhone and Google Maps methods) **:**

____

Total Acreage of Site Being Analyzed____

Obtain Soil Map of site using Web Soil Survey (WSS) website.

Use the site location information obtained above to find and print a satellite map using the Web Soil Survey website. Instructions on how to use the WSS can be found in Appendix D on pages 100 to 101, which provides a copy of an instructional brochure distributed by WSS managers. Search surrounding areas for protected areas and include them within the parameters of the map.

2.11 Protected Areas Surrounding Site

Protected lands surrounding the site may influence site preparation methods, including herbicide use, as well as seed mixes. For example, if remnant native plant communities of rare species exist locally, inclusion of these species would be forbidden in new roadside revegetation projects to prevent contamination of the remnant genetic population. The nearby presence of wetland areas or protected wildlife habitats could severely restrict the use of herbicides and insecticides. If any of the following protected areas are within 0.5 miles of the site, contact the state Department of Environmental Protection and/or Natural Heritage Program. The definitions following some of the protected land categories are those used by the IUCN (International Union for Conservation of Nature) :

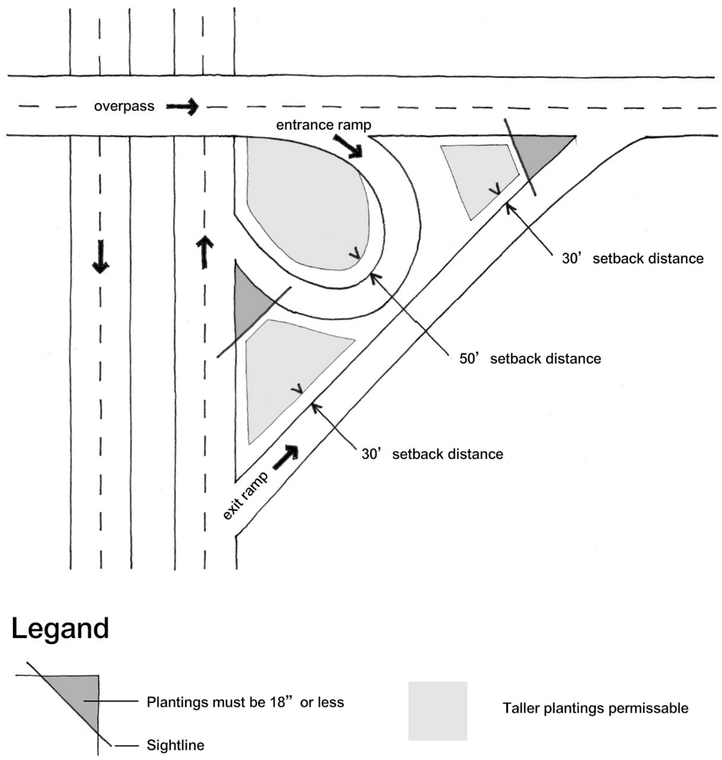
- **Wetland Areas**
- **Strict Nature Reserve:** strictly protected areas set aside to protect biodiversity and also possibly geological/geomorphical features, where human visitation, use and impacts are strictly controlled and limited to ensure protection of the conservation values .
- **Wilderness Area:** large unmodified or slightly modified areas, retaining their natural character and influence without permanent or significant human habitation, which are protected and managed so as to preserve their natural condition.
- **National Park:** large natural or near natural areas set aside to protect large-scale ecological processes, along with the complement of species and ecosystems characteristic of the area, which also provide a foundation for environmentally and culturally compatible, spiritual, scientific, educational, recreational, and visitor opportunities.

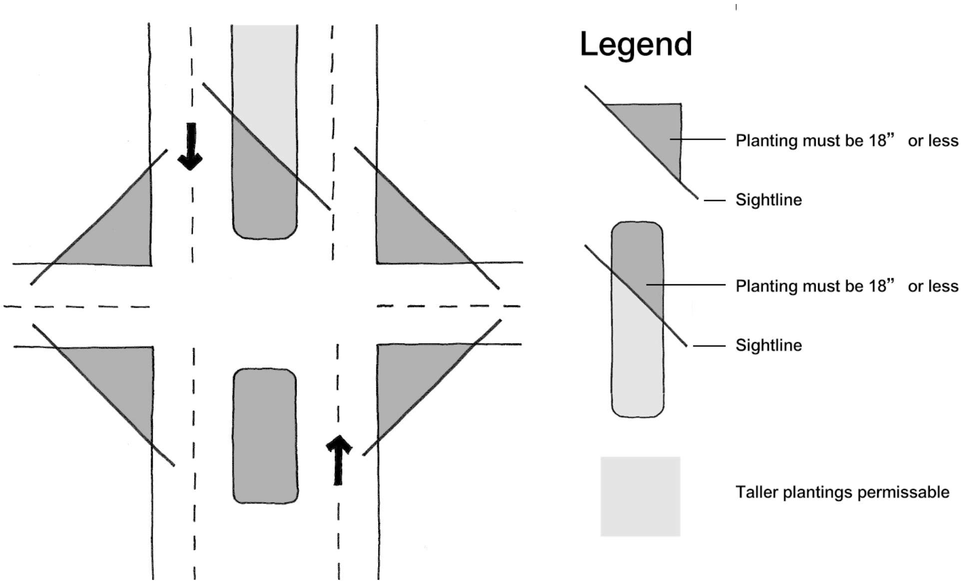
(Continued on next page)

- **Natural Monument or Feature:** a specific natural monument, which can be a land-form, sea mount, submarine cavern, geological feature such as a cave or even a living feature such as an ancient grove.
- **Habitat/Species Management Area:** Protected areas aiming to protect particular plant or animal species or animal habitats
- **Protected Landscape/Seascape:** A protected area where the interaction of people and nature over time has produced an area of distinct character with significant, ecological, biological, cultural and scenic value.
- **Protected area with sustainable use of natural resources :** Protected areas that conserve ecosystems and habitats together with associated cultural values and traditional natural resource management systems. They are generally large, with most of the area in a natural condition, where a proportion is under sustainable natural resource management and where low-level non-industrial use of natural resources compatible with nature conservation is seen as one of the main aims of the area.
- **Not within 0.5 miles of a protected area**

2.12 Roadside Limitations

Preserving Safe Intersections, Exits, On-Ramps, and Medians





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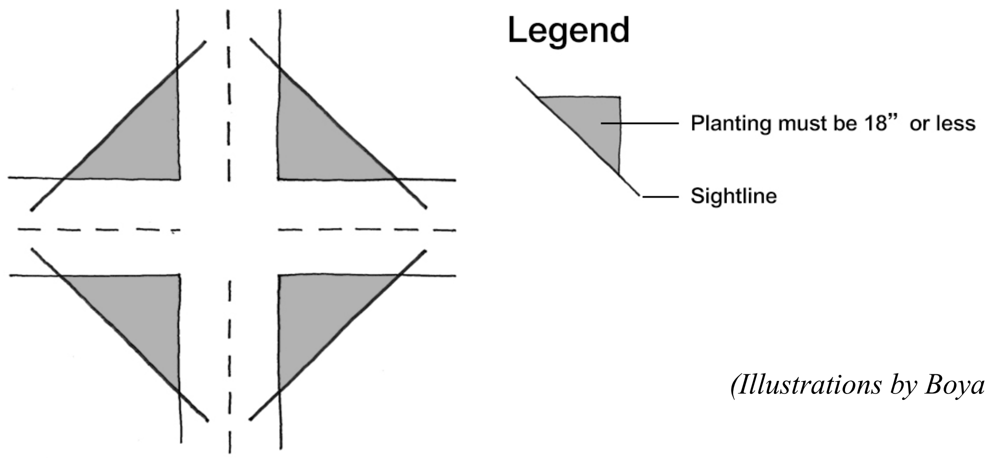
(Illustrations by Boya Yuan)



(Illustrations by Boya Yuan)

The top priority for any DOT is to provide a safe and efficient transportation system. Plant selection and location design help contribute to safe travel by maintaining sight lines and clear zone recovery areas. **Delineating the following roadside zones on the WSS map will help with plant selection and seed calculation.**

Lines of sight:

Maintaining clear lines of sight is essential for safe driving. If any portion of the planting sites are located near the following road interchanges of structures, choose low-growing plants that grow no more than 18" tall and avoid any species that can grow tall, such as grasses like big bluestem (*Andropogon gerardii)* and forbs like spotted Joe-Pye weed (*Eutrochium maculatum*) :

- ☐ Site is located within or near **an exit** or **on-ramp**
- ☐ Site is located near **an intersection**
- ☐ Site is part of **a median**
- ☐ No site restrictions apply

Presence of Guard Rails, Barrier Curbs, and Directional Signage

It is important that roadside plantings do not interfere with the visibility of guard rails, barrier curbs and directional signs. Overgrown vegetation can obscure visibility of these structures , creating hazards for drivers. Planting especially low-growing vegetation around these structures will help minimize the amount of time-consuming maintenance such structures usually require.

☐ **Guard rail** Yes No (Length: __________ feet)

☐ **Barrier curb** Yes No (Length: __________ feet)

☐ **Directional signs** Yes No # of signs at site __________

☐ No guard rails, barrier curbs or directional signs in area being assessed.

Utility Structures

Plans for planting should take into consideration the need for maintenance of and access to utility structures. Planting around these structures with low-growing vegetation and grasses that can withstand frequent mowing will help insure proper access to utility installations.

☐ Above ground high voltage electric wires

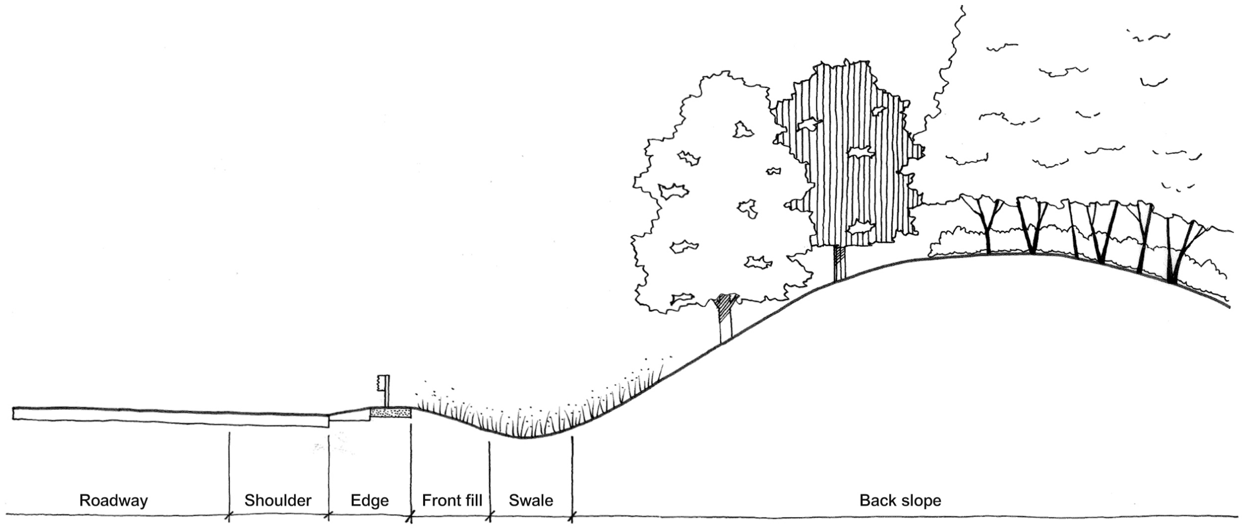
☐ Control boxes requiring access

☐ No utility structures in area being assessed

Stormwater Drainage

The presence of stormwater drainage conduit openings will greatly affect soil drainage capabilities. Documenting the location of stormwater drainage conduit openings on the WSS Map will help to understand the site's hydrology by outlining those areas on the site that experience more frequent periods of flooding or, in the case of catch basins, help document the patterns by which stormwater travels across and is removed from the site. It is important to select species that help facilitate desirable hydrology. Plantings relative to these structures should help increase stormwater soil infiltration, help prevent soil erosion, and not impede drainage into these structures.

- ☐ **Stormwater Drain Outlets** that empty stormwater onto site: # on site ___________
- ☐ **Pipe Culverts** that allow water to flow under a road onto site: # on site ___________
- ☐ **Stormwater Drain Inlet/Catch Basins** that remove stormwater from site: # on site __________
- ☐ No stormwater drainage structures in area being assessed



(Illustrations by Boya Yuan)

Roadside Zones

- **Roadside zones:** Depending upon location, speed limit, and roadside topography, roadsides typically contain up to five roadside zones. These zones play important roles in maintaining driver safety and influence landscape structural integrity by preventing soil erosion and assuring stormwater drainage.
- **Clear Zones** provide areas along the roadside for drivers to pull over in case of emergency or for errant vehicles to regain control after running off the road. The **shoulder/ approach** and **border/edge zones** especially require proper clearance to provide a safe environment for vehicles. Even after roadside mowing regimes become less frequent, the border/edge zone will still require frequent mowing. Tall grasses within the border/edge zone can be fire hazards resulting from the heat of vehicle engines, undercarriages, or exhaust pipes. Border/edge zones planting should continue to consist of grass species that can withstand multiple mowings each year.

(Continued on next page)

- **Slopes and Swales** play roles in the removal of stormwater from roads. Swale zones require the planting of species that can withstand temporary flooding.
- Plantings on **front slopes**, such as warm-season grasses, help slow run-off and increase water infiltration.
- **Back slopes** are usually steeper than front slopes and will require plantings that prevent soil erosion.
- If any of the following zones exist at a site, delineate them on the WSS map. This will help with measuring the size of the areas each encompasses and will help with seed mix calculations. For example, the portion of the landscape through which the swale zone runs will require a proportional amount of seed of species adapted to temporary flooding. Sloped portions of the site will require seeding that can quickly insure erosion control, especially if it follows new construction. In addition, slopes will require greater quantities of seed to compensate for seed dislodgement following rain events.

☐ Shoulder/approach zone

☐ Border/edge zone

☐ Front/fill zone - area covered ________________________________

☐ Swale/ditch zone - area covered ________________________________

☐ Back slope/cut slope - area covered ________________________________

2.13 Roadside Topography

Sun exposure: Sun exposure may vary from site to site depending upon the relationship of the area to a woodland’s edge or transportation structures , such as bridges. If such differences exist, delineated them on the WSS map.

☐ Full sun (up to 20% of ground is shaded) - total area___________________________

☐ Partial sun (20% to 70% of ground is shaded) - total area___________________________

☐ Shade (more than 70% of the ground is shaded) - total area___________________________

Slope grade : Slope grade will influence mulch, cover crop, and erosion control requirements. Delineate and designate the variance in steepness on the WSS map.

☐ Flat to 1:20 (5%) slope - total area___________________________

☐ 1:20 (5%) to 1:10 (10%) slope - total area___________________________

☐ 1:10 (10%) to 1:3 (33%) slope - total area___________________________

☐ Steeper than 1:3 (33%) slope- total area___________________________

Slope aspect: Steep south and west facing slopes, which receive more direct sun, are hotter and drier while steep north and east facing slopes, which receive less direct sun, are wetter and shadier.

Circle all aspects that exist on the site. In addition, label the aspect of each slope on the WSS map

North East South West

2.14 Soil Conditions

Herbicide use on site within three years of seeding

Carry-over from applications of particular herbicides may adversely affect native seed germination. If any of the following herbicides have been used within three years prior to seeding, note locations on the base plan where the herbicides were used and wait to install native seed in these areas until the sites are free from carry-over. Use temporary erosion control cover crop, which are usually less susceptible to herbicide carry-over, until these areas are ready for seeding.

Check any if any of these herbicides were used within the last three years from present date: _____________

☐ **Aminopyralid** (Milestone®, Chaparral®, CleanWave®, ForeFront®, GrazonNext®, Opensight®)

☐ **Picloram** (Tordon®, Grazon®, Access®, and Pathway®)

☐ **Clopyralid** (Stinger®, Transline®, Reclaim®, Curtail®, Confront®, Clopyr AG®, Lontrel®, Millennium Ultra®, Millenium Ultra Plus®, and Redeem®)

☐ **Atrazine**

☐ Other____

☐ None were used in last three years

☐ Not known

Selecting Tests for Determining Soil Characteristics

Soil tests provide important information when selecting native plants for a site. One of the advantages of using native plants is their strong adaptation to a region's soils and climate. However, not all native New England species are able to thrive under every soil or climatic regime. Therefore, matching seed mixes to a site's particular soil profile is essential for plants to persist longer and prevent the need for soil amendments. This checklist provides four different soil tests from which to choose. The following list is prioritized in the order in which they are recommended *(Check tests performed)*:

☐ **State Cooperative Extension Soil Test** (form on p. 19-20)

☐ **Percolation Tests** (form on p. 21-22)

☐ **Texture by Feel Test** (form on p. 23)

☐ **Redoximorphic Features** (explanation of test on p. 18)

It is highly recommended that the first two tests—the State Cooperative Extension Soil Test and Percolation Test—be conducted at each site. Together, both tests should provide sufficient data when selecting plant species. For example, if percolation test results indicate that a portion of a site has poorly draining soil, a seed mix for that area would need to include species that are able to withstand extended periods of moisture. In addition, soil test results pointing to a mesic soil regime implies potentially greater weed pressure after seeding than would occur at a drier site. Furthermore, soil tests conducted by the extension service may show extremely low levels of nutrients. In such cases, it is important to include plant species that can tolerate nutrient poor soils. Perhaps, only warm-season grasses and a few , *if any*, forbs would establish on such a site.

On-site Texture by Feel Test (form on p.23): This is a good, inexpensive preliminary test that is particularly helpful if a site appears to have more than one soil texture. When conducting the test, collect samples from the top 3 inches of soil since this is the depth at which seedlings will take root. If soil compaction is suspected, collect soil from the top 6 inches of soil.

Since this is a quick and easy test to conduct, it is recommended that several tests be carried out, especially if the site has varying elevations or distinctively different plant communities. If more than one textural class is found, you can determine whether several Extension or Percolation tests need to be conducted on these different areas. If more than one Texture by Feel test is conducted and find varying textural results for different areas at the site, document the results found on that area of the WSS map. This information will help with plant selection.

On-Site Test of Redoximorphic Features: Tests of Redoximorphic Features should be reserved for more problematic sites that display either poor seedling establishment or extremely poor drainage. This is the most time consuming soil test and usually requires a trained soil scientist to conduct—although, with proper training, a field person can learn how to properly conduct this test for most sites.

Tests of redoximorphic features help determine soil drainage classes by examining the coloration of soil layers, known as mottles. The soil colors provide information concerning the reduction of particular minerals resulting from seasonal levels of soil water saturation.

Since this test requires a higher level of expertise and greater amount of time to conduct, it is probably the most expensive. However, it will likely provide some of the most valuable information for determining drainage classifications and soil texture. Contact your state's land grant universities or NRCS offices to find soil scientists trained to conduct such tests.

State Cooperative Extension Soil Test

Soil tests analyzed by state land grant university cooperative extensions provide extensive soil information for an affordable fee. Search on-line for the forms for your state and the method for collecting and sending soil samples. Document the results of the test below or staple the results to this checklist.

Soil texture: If a site has large areas with varying topographical features, more than one soil test may be required. Delineate and designate any changes in soil texture on the WSS map of the site. Measuring the total area covered by each texture class will help when calculating seed mix amounts suitable for that soil texture. Each state has different test result formats. Some states do not include optimal nutrient or organic matter ratings.

☐ Sand - total area______________________________

☐ Sandy loam - total area_________________________

☐ Loam - total area______________________________

☐ Clay loam - total area__________________________

☐ Clay - total area_______________________________

☐ Other- total area_______________________________

pH: _________

Organic matter content: ________% ☐ Low (< 4%) ☐ Medium (4%-8%) ☐ High (> 8%)

(Continued on next page)

Soluble Salt Level: ___________ms/cm

- **< 0.4 ms/cm**: Low, safe for most all plants
- **0.4-0.8 ms/cm**: may cause damage to saline sensitive plants
- **0.81—1.2 ms/cm**: Will restrict the growth of many plants
- **> 1.2 ms/cm**: likely to cause plant damage

Calcium: _____________ppm

Very Low Low Optimal High Very High

Magnesium: __________ppm

Very Low Low Optimal High Very High

Potassium: ___________ppm

Very Low Low Optimal High Very High

Phosphorus: __________ppm

Very Low Low Optimal High Very High

Percolation Tests

“Perc” tests measure the rate at which water moves through a soil profile. These tests are rather straightforward and can be conducted by any trained field person..

The macroporosity of a site’s soil will influence the rate of water flow. The higher the soil porosity, the greater the soil aeration as well as the rate of soil water infiltration. Relative soil moisture infiltration will influence site plant selections. Perc tests resulting in particularly slow water infiltration can pose serious problems for plant establishment because a site’s soil may display high surface runoff, soil erosion, seed loss, and hypoxic (low oxygen) conditions.

There are various tools available to measure this. In absence of these tools, the instructions on the following page are useful but less precise substitute

Performed by____

Date ________________ Time__________________

Tools used:____

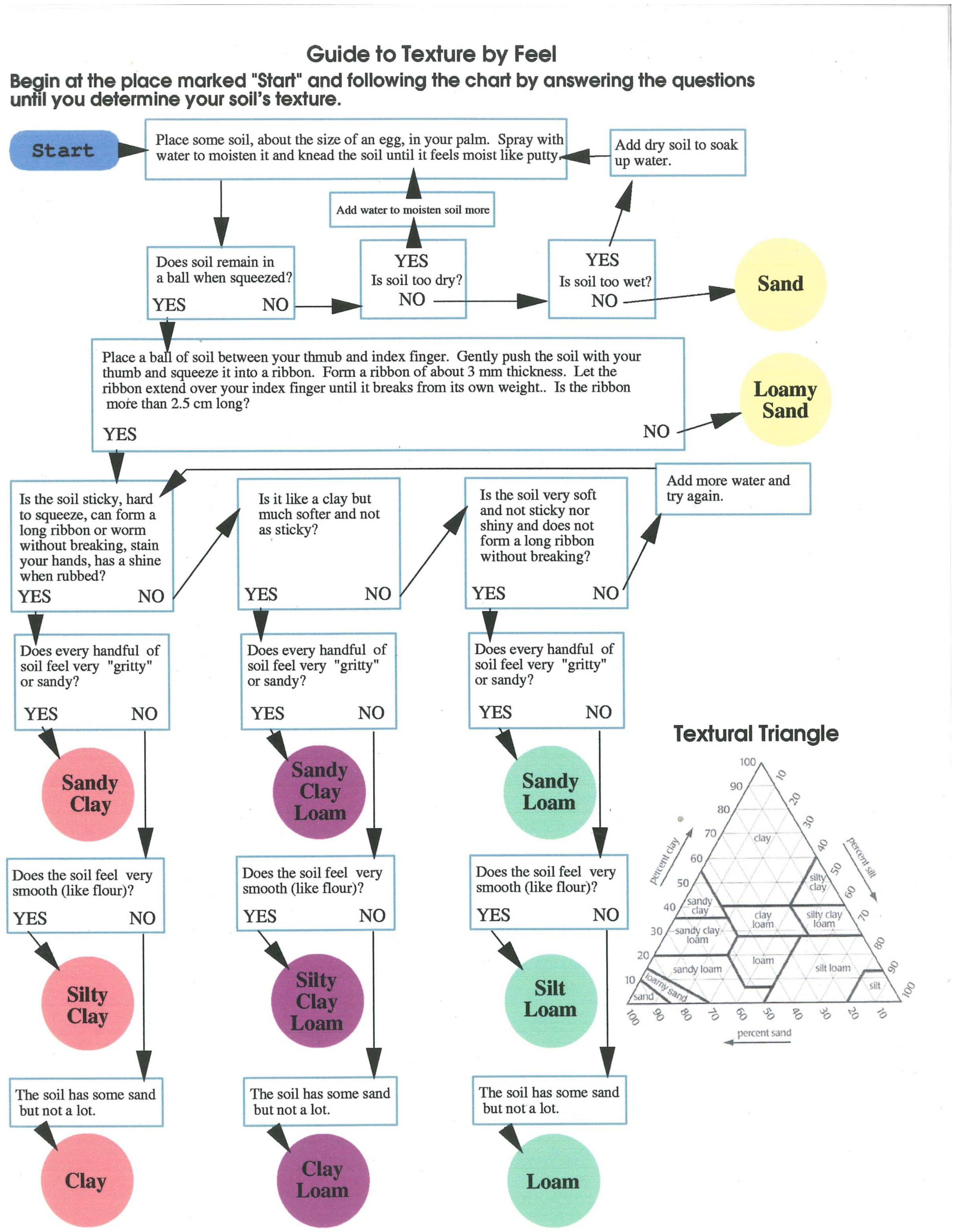
Notes (such as initial moisture and other relevant information):

How to Conduct a Percolation Test

- **The best time to conduct perc tests is after a significant rain event, when the soil is moist.** This factor is important because, if the soil surrounding the test hole is dry, the adhesive forces of the dry soil will pull the soil water laterally. Therefore, if it is not possible to conduct the test following rainfall, it is critical that the soil within a foot or two of the hole be as wet as possible.
- **If the soil is particularly dry**, fill the hole several times with water and thoroughly wet a one-foot area surrounding the hole.
- **Start by first removing the turf in the area being tested and dig a hole** with an opening measuring around one square foot. Dig down 12 to 18 inches, making sure to remove the soil.
- Once the soil surrounding the hole appears saturated, **fill the hole to the soil surface with water. Immediately measure the height of the water** in the hole using a yardstick.
- **Wait 15 minutes** and **once again measure the height of the water**.
- **Subtract the second reading from the first one** to determine the rate of drainage over 15 minutes. **Multiply this rate by 4 to determine inches drained per hour.** Since some water will still be pulled horizontally, the resulting calculation will likely be an overestimation.

Soil Drainage Rates:

- < 1inches/hour = **poor drainage**
- 1 to 4 inches/hour = **moderate drainage**
- > 4 inches/hour = **excessive drainage**



Adapted by UC Cooperative Extension Master Gardener Program from: Thien, Steve J. 1979. "A Flow Diagram for Teaching Texture-by-Feel Analysis." *Journal of Agronomic Education*, 8:54-55.

2.15 Inventory of Existing Vegetation

- The best time to conduct plant inventories in New England is usually from early August to the beginning of fall when warm season grasses have begun to flower. It is usually easier to identify plant species, especially grasses, from their flower and inflorescence morphologies rather than from their leaf morphology.
- While a botanist trained in identifying plant species would be the first choice for conducting a plant inventory, few DOTs have access to one. Those persons conducting site inventories will require training to identify regional roadside plant species. **Existing Thriving Plant Species Tables** include a space for documenting **Wetland Indicator Status** (WIS). While not a perfect method, WIS can help point to classes of species that thrive under similar conditions. However, it should be noted that cataloguing plant WIS is not a substitute for soil testing or indicator of a sites wetland status.
- Plant species require a range of soil and climatic conditions to thrive. Therefore, if an inventory of a site's vegetation reveals, for example, a collection of plants best adapted to dry, sandy soils, then the seed mix should include species that can thrive under similar conditions. Species composition can change within a site depending on hydrologic and climatic conditions. For example, low lying areas and those exposed to drainage outlet runoff may be populated by species that can withstand temporary flooding. It is important to delineate these varying site conditions on the WSS map. If a site has more than one set of soil or climatic conditions, it might be beneficial to print more than one set of Existing Thriving Plant Species Tables.

- If an inventory reveals colonies of native species, then site preparation should use techniques provided in the Establishment chapter that help preserve these native colonies. This not only saves time and money, but also preserves local populations that have already adapted best to the region's climatic conditions.

Existing Thriving Plant Species Tables

Native New England Plant species	Estimation of % Coverage	Wetland Indicator Status

Undesirable plant species (other than invasive plant species)	Estimation of % Coverage	Wetland Indicator Status

Invasive Species growing within site to be planted

- List below the invasive species growing within the site and note the extent of each species on the WSS map.
- High invasive species cover will require significant site preparation to eliminate or minimize invasive species pressure prior to planting.
- Consult state invasive species experts and manuals for guidance in combatting particular invasive species before planting new vegetation.
- If limited maintenance resources exist, significant invasive species pressure should be expected. In such situations, design a seed mix able to compete with anticipated invasive species.

Invasive Species (I.S.) growing within site to be planted	**% Cover**	**Estimated surface area covered by I.S.**	**Will I.S. roots and seed be removed prior to seeding?**

Invasive Species growing adjacent to site

- Although invasive species may not exist within the boundaries of the site, their aggressive ability to spread puts new plants at risk if colonies of invasive species border the new planting site. Eliminating or using methods to control these adjacent invasive colonies will help to prevent their overwhelming the newly revegetated site.
- List in the table below the invasive species growing adjacent to the site.
- When delineating the Areas of Interest when creating the WSS map, be sure to include portions of surrounding areas where invasive species colonies exist.
- Consult state invasive species experts and manuals for guidance in combatting particular invasive species before planting new vegetation.

Invasive Species (I.S.) growing adjacent to site	**% Cover**	**Estimated surface area covered by I.S.**	**Will I.S. roots and seed be removed prior to seeding?**

Indicators of stress on existing species

- ☐ Interveinal chlorosis
- ☐ Chlorosis
- ☐ Leaf wilting
- ☐ Marginal leaf scorch
- ☐ Premature fall coloration
- ☐ Stunted growth

Species affected by stress	Stress Symptoms

Acknowledgement: Road maps and cross section illustrations drawn by Boya Yuan from the University of Connecticut

III: Establishment Methods for Native Plant Communities

While native plant communities provide more long-term ecological and economic benefits compared to non-native cool-season turf grasses, the establishment of biodiverse native plantings require more intensive protocols than monocultural cool-season turf grasses. Unlike cool-season turf grasses, which can be seeded and established within one growing season, native warm-season grasses and forbs not only germinate more slowly but each species frequently has differing establishment patterns. As a result, a community of native herbaceous plants can take three to five years to fully establish.

The establishment of native plant community requires consideration of the three following components:

- Site Preparation
- Seeding
- Post-establishment monitoring and maintenance

Because each project has its own unique circumstances, the priority managers give each of these components will change depending upon the timing of different variables.

This chapter covers each of these components and describes various scenarios that need consideration in the course of native plant community establishment. Becoming familiar with each of these steps will help increase the likelihood for long-term success.

3.1 Site Preparation

The composition and density of the existing vegetation will determine the amount of pre-planting site preparation required. It's essential to survey a site well before planting takes place to develop an approach to the establishment of natives and to allow adequate time to complete successful site preparation. A thorough plant inventory of a site will provide useful information concerning the level of noxious and aggressive weeds and/or invasive plants present. If significant quantities of undesirable vegetation exist, it may take a year or more to control them before planting, especially if planting in a large area.

The biggest challenge when establishing native plant communities is often competition from non-native vegetation, whether from non-native cool-season turf grasses that DOTs have established intentionally or weedy and invasive species that have infiltrated roadsides inadvertently. Undesirable species compete with native plants for resources, including light, soil space, nutrients, and water. Since cool-season grasses start to grow at temperatures lower than those required for warm-season grasses cool-season grasses have a head start of several weeks to compete for available resources. In addition, weed species commonly found along roadsides readily adapt to ruderal environments – *disturbed* habitats where soil or natural vegetative cover frequently gets damaged, usually as a result of vehicular intrusions. In fact, disturbances give weed seeds the resources they need – especially in the form of light – to germinate and outcompete non-weedy species.

To achieve optimal results, it is best to start weed control at least a year in advance, whether using herbicides or especially when herbicides are prohibited. It is also important to keep in mind the time at which seeding will occur. It is helpful to choose the seeding time before site

preparation, taking into consideration who will be conducting the seeding, what equipment will be needed, and which species will be included in the mix. Working backwards, determine what steps can be taken beforehand to insure that the planting area is as well-prepared and weed-free as possible.

Two main scenarios exist after which native plant revegetation would take place:

- **Establishing all new vegetation following construction**
- **Transitioning current roadside vegetation to native vegetation**

Each scenario presents different challenges.

(Sidebar: Site Preparation – See Appendix E, p.102)

3.1.1 Establishing all new vegetation following construction

Prior to construction, work crews remove existing vegetation when skimming the topsoil surrounding a construction site. After construction completion, either the stockpiled topsoil is returned or new, weed-free topsoil is brought in. Rarely does a weed-free, vegetation-free area ever exist before planting along roadsides. Determining whether significant quantities of weed propagules exist in a site's topsoil will help guide the decisions for effectively preparing a site for planting. Since construction subjects a site to major disturbance, weeds may overwhelm the site following construction completion if the soil is full of weed seeds or viable roots. If noxious or aggressive weeds are not suppressed prior to planting, these weeds could be very difficult to kill in a new planting without destroying the newly established desirable plants.

Effective establishment of native plant communities on vegetation-free soil requires determination of the optimal time for seeding. Site preparation will depend upon when in the calendar year the construction ends. If construction ends during a less than optimal time for seed planting, a cover crop may be needed for erosion control and/or to reduce future weed competition.

If a significant weed problem is expected, it is important to plant a temporary *annual* cover crop – *Avena sativa* (grain oats) from spring to August 1st; *Secale cereale* (grain rye) thereafter. Then, the following year, plant the native grasses.

3.1.2 Transitioning current roadside vegetation to native vegetation

Part of the previous site analysis chapter requires an inventory of existing vegetation followed by determination of which establishment method best suits the particular site conditions.

Preparation for a site with existing vegetation will depend upon the presence of native species populations and the composition of these populations. There are two scenarios:

- Establishment of new native plantings
- Augmentation of existing native plant communities

3.1.2.1 Establishment of new native plantings on current roadsides

If a section of roadside is to be transitioned from existing vegetation of typical introduced cool-season grasses and broadleaved weeds to a native plant community, it is essential to eliminate competition with pre-existing vegetation before planting.

The existence of cool-season turf grasses and weeds create a considerable barrier for warm-season plant establishment when transitioning current roadside vegetation to native vegetation. Since cool-season plants start to grow at temperatures lower than those required for warm-season plants, they have a head start of several weeks to compete for available resources. In addition, warm-season grasses are slow to germinate and exhibit less seedling vigor than weedy species.

Unfortunately, eliminating undesirable vegetation is not a one-step process. Even if cool-season grass and weeds are killed with an application of broad-spectrum herbicide before warm-season grass seeding, competition can still come in the form of warm-season weeds, such as crabgrass (*Digitaria sanguinalis*), goosegrass (*Galium aparine*), barnyardgrass (*Echinochloa crus-galli*), yellow foxtail (*Setaria pumila*), common purslane (*Portulaca oleracea*), pigweeds (*Amaranthus* sp.), lambsquarter (*Chenopodium album*), carpetweed (*Mollugo verticillata*) , and prostrate knotweed (*Polygonum aviculare*). Since these weeds usually establish more easily, grow faster, and produce an abundance of seeds that can remain viable in the ground for many years, they can rapidly outcompete warm-season grasses and forbs.

It is important to make clear that the most efficient, effective, and budget-conscious methods for weed elimination involve the use of herbicides. However, it is also important to acknowledge that many municipalities and state governments not only discourage but outlaw their use. Therefore, this manual will provide alternative methods to herbicide use but will stress that these methods not only require more time, labor, and expense but may lead to less satisfactory results unless carried out with vigilance. Nevertheless, herbicide-free native plant community establishment is a viable method and the inability to use herbicides should not be used as an excuse not to move forward with transitioning to roadside native plant vegetation. Combining

non-herbicide methods along with those involving herbicide usually will lead to the most successful site preparation.

The Efficacy of Using Herbicides during Site Preparation

The majority of herbicide use in the establishment of native plant communities occurs on the front end of the process. Also, in all likelihood a seed bank of both annual and perennial weeds will emerge with the planting, necessitating follow-up weed control.

If the procedures spelled out in this manual are carried out properly and any herbicide use strictly follows the instructions included with the product, any long-term impact on the environment or the health of those working with the herbicides and the general public can be minimized. In addition, since dense native plant communities provide the best defense against continued weed and invasive species encroachment, the need for herbicide use becomes less over the long-term.

Before any herbicide application, those applying herbicides should carefully read relevant literature concerning recommendations for treatment, including specific herbicides, rates, and timing. State land grant colleges can provide published sources of information based on the current manufacturer's labeling and annual reviews. If published recommendations are not available or additional information relating to herbicide treatment methods is desired, seek advice from the manufacturer using the contact information provided on the label and Material Safety Data Sheets (MSDS) or from a consultant with the appropriate state pesticide applicator certification. If using herbicides as part of the establishment process, it is advisable to check with the state conservation department whether the roadside being worked borders ecologically protected land. Pesticide use could be restricted in such a situation.

Choosing an Herbicide

Choosing an herbicide will depend upon the existing plant community. If no desirable plant communities exist, choose a non-selective herbicide such as **glyphosate**. However, glyphosate can also be used where desirable native warm-season grasses exist as long as it is used before warm-season grasses break dormancy. Since glyphosate is a systemic herbicide, it requires the presence of leaf surface into which the herbicide can penetrate. As long as warm-season grass blades have still not started to emerge, glyphosate can safely be used without damaging dormant warm-season grasses. For extremely vigorous turf or weeds, plan to make one application of herbicide in early fall, followed by another the next spring before planting.

Selective herbicides usually work by targeting either monocots (grasses and species such as sedges) or dicots. Since the most ecologically balanced native plant communities consist of both grasses and broadleaved forbs, it may be challenging to plant both grasses and forbs in the same mix, especially if existing weed communities have not been fully eradicated. If the pre-existing plant community contains warm-season broadleaved weeds, it may be advisable to use the spring to establish just the warm-season grasses and plan to conduct a dormant seeding of forbs in the fall. Under this scenario, plantings of grasses with no broadleaf forbs or legumes may use broadleaf foliar herbicides. Following warm-season establishment, if broadleaved weeds or invasive species emerge, a selective herbicide such as 2,4-D may be used for spot treatment. Follow all label directions when using herbicides, and keep in mind herbicide persistence/carryover as it may affect new plantings. Usually, grass seedlings need to be at the 4- to 5-leaf stage prior to a broadleaf contact herbicide application to avoid herbicide injury. Do not plant native grasses before having sufficiently controlled competing non-native grass vegetation.

It is far easier to control grass vegetation competition before planting than it is to do so afterward.

The selective herbicides **Plateau®** or **Panoramic®**, imazapic-based herbicides, are well suited for native plant community establishment. When used properly, Plateau® or Panoramic® will kill plants with faster metabolisms. Most native warm-season grasses and native forbs, such as partridge pea, black-eyed Susan, yarrow, and perennial lupine, are tolerant of Plateau® or Panoramic®, when used at the proper concentrations.

Herbicide Carryover

Carryover from herbicide treatments in prior years can pose a threat to new plantings. Seedlings are particularly sensitive to herbicide carryover. The herbicides recommended in this manual, such as glyphosate and Plateau, have very short persistence and generally do not pose a risk for carryover. Herbicides such as atrazine have medium to long persistence and can pose a risk of carryover. If the information is available, it is helpful to know what, if any, herbicides were applied to a site and when before apply more herbicide. The persistence of herbicides is affected by factors such as soil pH, organic matter, texture moisture, and chemical half-life.

If herbicide carryover is a concern, read the herbicide label, or contact the manufacturer or a consultant. However, if time permits, conduct a bioassay by potting some of the soil and planting a small portion of the seed mix to observe the impact. In conducting the evaluation, check both the roots as well as the top growth for any carryover damage.

Using Organic Herbicides

One of the most commonly suggested organic herbicide choice is vinegar-based herbicide. Horticultural vinegar contains 20% Acetic Acid. To be fully effective, vinegar-based herbicides

will require at least three applications over a growing season. However, it should be noted that many in various horticultural industries who, either by choice or by regulation, have turned to organic herbicide use have found that acetic acid is effective only on seedlings. When applied to mature, established vegetation, acetic acid will only kill the upper portion of the vegetation and leaves the root zones intact, ready to regenerate.

Applying Herbicides

The timing of the herbicide application will determine which herbicides are to be used.

The herbicides usually used are either glyphosate or imazapic-based Plateau®, Panoramic® or Journey®, which contains both imazapic and glyphosate.

Glyphosate is a non-selective systemic herbicide that will kill all vegetation present. It can be applied during growing season.

Because of their selectivity, Plateau® and Panoramic® can be used during either the fall or in the spring. In the fall, it is best to be used mid-to-late in the season, when perennial plants are translocating nutrients to their roots for winter dormant storage. Mid-autumn spraying of Plateau® or Panoramic® has the advantage of giving the remaining native plants time to take advantage of the extra soil space left open once the undesirable vegetation has been eliminated.

In the spring, either glyphosate, Plateau®, Panoramic® or Journey® can be used. Because Journey® contains both imazapic and glyphosate, some studies have suggested that it works as both a post- and pre-emergent (Bahm 2015), thus eliminating pre-existing vegetation and suppressing the re-emergence of competitive non-native grasses and weeds. Applying herbicide under this scenario, it is best to apply one of the herbicides just before native warm season grasses emerge. Native warm-season grasses, such as little bluestem, purpletop, and switchgrass,

break from dormancy when the soil temperatures are above 70° F. Such temperatures usually occur when daytime air temperature reaches around 80° F. Night time temps also provide a good indicators of the soil temps. When night time temps are between 65-70 ° F, soil temperatures will likely be very close to the same temperature. In New England, these ranges temperatures arrive in early to late May.

Tilling

One of the best ways to kill existing vegetation without chemicals is to till the soil, thus uprooting and burying the existing vegetation. While such a procedure can effectively kill existing vegetation, it does involve soil disturbance.

Unless weed seed reserves have been exhausted, weed pressure will present a future challenge. Exhaustion of weed seed reserves to decrease competition requires **several rounds of tilling** spaced several weeks apart in order to kill the weeds that will germinate as a result of the tilling. This method is recommended when municipalities prefer not to use herbicides. However, even if a municipality does allow the use of herbicides, exhausting weed seed banks as part of site preparation can help minimize herbicide use later in the process.

Cultivation is usually less effective than herbicides for killing heavy sod or persistent weeds. Also, bare ground produced by cultivation may be vulnerable to erosion. For this reason, non-herbicidal methods are recommended only for level ground. Slopes are subject to extensive erosion from the following process.

An initial tilling at a depth of 3-6 inches will kill most weeds. Subsequent shallow tillings at approximately 2-3 inches deep will eliminate newly germinated weed seedlings. This will gradually reduce the amount of weed seed present in the soil. It is important to keep subsequent tillings shallow to prevent more deeply buried weed seeds from being brought to the surface.

This method often requires several tillings spaced out over several weeks and months. Usually one tilling every three weeks. It would be important to start these tillings as early in the season so that as many passes can occur. Only when weed seed germination has been minimized will the field be clean enough for native plant establishment. Since this process should take the entire summer, it may be best to plant a cover crop of cereal rye (*Secale cereal*) in the fall to prevent weed encroachment and soil erosion during the winter. If the weed seed germination becomes minimal during the summer, planting a buckwheat (*Fagopyrum esculentum*) smother crop followed by fall planting of cereal rye (*Secale cereal*) or winter wheat (*Triticum aestivum)* is advisable. Planting would then take place the following spring after tillage of the cover crops into the soil.

Using Flame Guns for Spot Weeding

Some Midwestern, Western, and Southern DOTs use controlled or prescribed burning to manage invasive plant species encroachment into roadside native grasslands, wetlands, and woodlands. Many native ecosystems have evolved with fire as a contributor to habitat vitality and renewal. However, while many New England conservationists use prescribed fire as a tool to renew habitats for threatened animal species, such as the New England cottontail, or to renew remnant native plant communities, such the world's largest population of northern blazing star (*Liatris novae-angliae*) found in Maine's Kennebunk Plains, this manual does not recommend using prescribed fire along New England highway roadsides. Considering the traffic density on most

New England highways, the smoke resulting from prescribed burning would obscure visibility and cause safety issues for drivers.

Nevertheless, for those DOTS concerned about using herbicides to manage weed and invasive species re-encroachment during the monitoring and maintenance portion of native plant community establishment, flame guns powered by a butane gas canister provide a non-chemical method to burn off the sprouting tops of weeds. The heat of the fire boils the water in the plants' cells, causing them to burst and die. This method works best against annuals and woody seedlings, and has the added advantage of burning some of the weed seeds lying close to the surface. This technique requires just a quick swipe over the weeds, which immediately boils the water inside the plants' tissues.

3.1.2.2 Augmentation of Existing Native Plant Communities

Pros:

- Increases local, genetically-adapted plant material
- Lower in cost and faster than establishing new plantings using seeds, plugs, or potted plants
- Less time, labor, and resource intensive

Cons:

- Challenging to preserve populations of native cool-season grasses that co-exist with native-warm season grasses

New England roadsides have the distinct advantage, especially compared to those in other regions of the United States, of having an abundance of pre-existing, ecotypical native plant communities, often consisting of such native grasses as little bluestem and purple love grass, as well as goldenrods and asters. In some cases it is practical to preserve and increase these communities. Not only is this more economical, but it is ecologically sound. This approach to revegetation involves promoting natural regeneration rather than introducing new plant material – whether in the form of seed, plugs, or potted plants – which require more time, labor, and resources.

The strategy of revegetation by way of augmentation of existing native plant communities should always take priority over planting new native plant communities. Not only does this approach preserve and increase the pool of local plants, which have evolved best to the New England climate, but it provides an effective path forward in transitioning to native plantings while the supply of regional ecotypical native plant seed remains limited.

The following method for augmenting pre-existing native communities involve:

1. Identifying existing native plant communities.
2. Delineating existing native plant communities.
3. Applying herbicides at the appropriate time to eliminate undesirable vegetation interspersed with the desirable native plant communities.

Identifying Existing Native Plant Communities

In many cases the option of promoting native plants already present at the site is sufficient to revegetate an entire portion of roadside. The consideration to select this option should be based on the abundance of native plants on a site determined during site assessment.

Identifying native plants can be difficult. One of the best strategies for identification involves becoming familiar with a species' flowers or, in the case of grasses, their inflorescences (flower clusters). An ideal time in New England for finding existing native grass communities is usually toward the end of August and into the fall. A good plant that indicates that it is time to scout for native plant communities is when purple love grass (*Eragrostis spectabilis*) comes into bloom. Purple love grass is a low-growing grass. Before it comes into bloom, it is easy to mistake its leaf blades for those of crabgrass. However, once it blooms, its inflorescences create seas of dusty lavender clouds, often right along the borders of the road itself. Once purple love grass is in bloom, other native warm-season grasses will also be in bloom, such as little bluestem (*Schizachyrium scoparium*), purpletop (*Tridens flavus*), switchgrass (*Panicum virgatum*), broom sedge (*Andropogon virginicus*) and Indiangrass (*Sorghastrum nutans*).

Experienced botanists will also be able to identify desirable native cool-season grasses, such as poverty grass (*Danthonia spicata*), slender oatgrass (*Danthonia compressa*), rough bentgrass (*Agrostis scabra*) and autumn bentgrass (*Agrostis perennans*), or the many sedges (*Carex)* native to the New England region. If a site is replete with these native cool-season grasses and grasses-like plants, the following techniques for augmentation through herbicide application is not advisable. The recommended herbicides will not insure preservation of these species.

Delineating Existing Plant Communities

Since herbicide treatment of these sites will happen toward the middle and end of fall or mid-spring of the following year, it is important to set up markers that will delineate native plant communities. This is especially important because DOT maintenance crews often mow during the fall months. Once a field is mowed and the flowers and inflorescence are removed, it is very difficult for anyone but trained botanists to identify existing vegetation.

Check with DOT regulations concerning the placement of markers along roadsides. Some DOTs will not allow the use of any markers that interfere with mowing regimens. Therefore, it is often best to use brightly colored plastic stakes with large heads that can be pounded flat into the soil. The large heads and bright colors will make it easier to find them in case they are buried beneath overgrown stands of vegetation.

Reduced mowing

When native plant communities exist at a site and state law prevents use of herbicides to help increase the density of the native stands, a DOT can choose to reduce mowing at the site during warm-season grass growth, thus allowing the native grass and perennial wildflower stands the chance to outcompete any cool-season grasses and weeds. This would mean mowing in early spring and late fall only. The later a mowing can be delayed, the more likely native warm season grasses and late blooming wildflowers can disperse their seed and increase the size of the community.

Applying herbicides

For sites requiring extensive preparation, much of the work should be done either during the mid-to-late fall prior to spring planting, or at the point prior to the emergence of warm-season

grasses – usually early to late May in New England, depending upon that year's soil temperatures. It is helpful to monitor soil temperatures to insure that any herbicide applications do not kill any existing native-warm season grasses emerging with the warming soil. Warm-season grasses break dormancy or start to germinate when soil temperatures exceed 60 to 65 degrees F.

Applying Herbicide from Mid-to-Late Fall

When applying herbicide during the fall to augment existing native plant populations, only two imazapic-based herbicides – Plateau® and Panoramic® – should be used. (See previous section on **Applying Herbicides** for more information concerning use of Plateau® and Panoramic® in the fall)

Applying Herbicide before Native Warm-season Grasses break dormancy in the Spring

When applying herbicide before native warm-season grasses break dormancy in the spring to augment existing native plant populations, the herbicides recommended for use are either glyphosate or imazapic-based Plateau®, Panoramic® or Journey®, which contains both imazapic and glyphosate. (See previous section on **Applying Herbicides** for more information concerning use of herbicides in the spring)

3.2 Seeding

Basic steps to successful seeding require:

- Familiarity with **proper timing for successful seed germination.**
- Use of **healthy, viable seed** suitable for the area in which it will be used.

- Insuring that the **native seed has direct contact with the soil**. **When possible pack seeds tightly** to the soil. Seeds be **buried no more than ¼ in. deep**.
- Where necessary**, include erosion control measures**, especially when seeding slopes, to prevent soil destabilization and dislocation of seed.
- **Mow weeds when they reach a height above 8"** during the first growing season to prevent annual weeds from flowering and setting seed, and to insure proper light for native seed germination and establishment.

3.2.1 Timing of Warm-Season Grass Seeding

A significant portion of native grasses consist of warm-season species. As a result, timing of planting differs greatly from that of non-native cool-season turf-grasses.

Cool season grass, such as fescues and ryegrasses, germinate best when soil temperatures are between 50° and 65° F. Such soil temperatures usually occur when daytime air temperatures are between 60° and 75° F. As result, the optimal time for turf grass seeding spans from early spring to early summer or early to late fall. Some cultivated cool-season grasses can even be dormant seeded in early winter for the following spring.

Unfortunately, successful warm-season grass establishment does not have as much flexibility when it comes to timing. Due to slow initial growth, warm season grasses, which ideally should have a growing season of 100 to 120 days to establish roots prior to winter, typically are seeded in New England within a window spanning from late spring to early summer.

Native warm-season grasses, such as little bluestem, purpletop, and switchgrass, grow best when the soil temperatures are above 70° F. Such temperatures usually occur when daytime air

temperature reaches around 80° F. Night time air temperatures also provide good indicators of the soil temperatures. When night time temperatures fall between 65° and 70° F, soil temperatures will likely correlate closely to the same temperatures. Cool temperatures can inhibit germination and cause adult plants to go dormant. Therefore, planting in the fall carries more risk because of potential damage to smaller seedlings from an early frost or freeze.

In New England, the optimal period for warm-season seed establishment happens between mid-May to late June. Specific timing will vary depending upon the hardiness zone in which the planting takes place. However, while warm-season native grasses – especially those grown from local seeds – are usually better adapted to the local climate and soil conditions, germination can suffer from insufficient moisture. The later the planting occurs into the summer months, the greater the possibility exists that high temperatures and drought could deprive the seeds of sufficient moisture. In such a situation, irrigation may need to be brought to the roadside site to prevent seed establishment failure.

4.2.2. Dormant Seeding

Dormant seeding is especially well-suited for forbs/wildflower establishment, which often benefit from the period of cold stratification during the winter months. Protect dormant seeding sites by mulching or applying erosion control blankets. These practices will not only protect the site against erosion, they will reduce freeze/thaw cycles and protect emerging seedlings from wind desiccation in the spring. Native cool season grasses, sedges and legume dormant seeding should occur just before soil freezes

Some practitioners have found success with dormant seeding warm-season grasses if they are included in a mix with native cool-season bunch grasses, such as wavy hair grass (*Deschampsia*

flexuosa), which will establish first in the spring and prevent weed and non-native cool-season turf grass competition. In such cases, conduct thorough site preparation to kill all weed and turf grasses present.

Hydroseeding works well with dormant seeding. Snow helps break down the mulch and the heaving of the soil from freezing and thawing helps create good seed-to-soil contact.

Increase seeding rates by 40 to 50 percent when dormant seeding, due to reduced germination, soil-borne disease, and insect predation. Fungicide seed treatments may benefit dormant seedings. Keep in mind that, in the Northeast, working the soil becomes difficult late in the season due to increased soil moisture. Consider conducting final grading or seedbed preparation earlier in the year while the soil moisture content remains at levels conducive to soil penetration.

No-till drilling or broadcasting with mulch may be possible alternatives if the soil surface dries enough to allow for tractor traffic. Avoid using tractors or other heavy machinery if the soil remains excessively moist. Mechanical disturbance and compaction could result in greater weed and invasive species pressure the following spring.

(Sidebar: Seeding Calendar – See Appendix H, p.106)

3.2.3 Seeding Methods

Selection of seeding method and equipment will depend upon:

- Site characteristics, including:
    a. Slopes
    b. Soil drainage

c. Size of area

- Type of seed
- The quality and extent of site preparation
- Availability of equipment

The seeding methods include:

1) Drill seeding
2) Hydroseeding
3) Sawdust as seed mulch
4) Broadcast seeding

3.2.3.1 Drill Seeding

Pros

- Convenient for planting large areas
- Seed drills have seed box agitators and depth controls designed specifically for planting small and fluffy native seeds at optimal rates and depth
- Allows planting into a light stubble layer
- Some models plant seeds in even rows, allowing for easier seedling recognition
- Plants seeds at optimal depths when correctly calibrated, thus eliminating the need to press seed into the soil surface after planting (e.g., cultipacking)

Cons

- Not suitable for slope seeding
- May be unsuitable for excessively rocky soils

- Seed drills are expensive and not readily available in many areas
- Requires a tractor and an experienced operator to set planting controls
- Seed with a lot of chaff, such as those of little bluestem, can clog delivery tubes

No-till seed drills, such as those produced by Truax, John Deere, Marliss, Tye, and Great Plains or the Greenscape Conservation Seeder, provide some of the fastest, most effective and efficient methods for planting native seeds because they drill seed to correct, uniform depths.

Native grass drilling is the preferred method on level right-of-ways. However, drills do not work on steep slopes. At 3:1 or steeper, the drill will likely slide sideways, causing the disk openers to dig in and bury the seed at an incorrect depth. Working on projects with silt fences present the added challenge of maneuvering the tractor and drill around these fences. Since silt fences are used to prevent soil erosion, the soil is frequently exposed and not anchored by vegetation. Under such circumstances, hydroseeding provides the preferred method of seeding.

Each brand of drill has different features and size ranges to suit particular situations. Typically designed for no-till seeding, native seed drills work by cutting through a variety of residues, soil types and soil moisture conditions. Seed drills usually have multiple hoppers designed to accommodate different seed types and sizes: small seeds, fluffy seeds, and cool-season/grain seeds. Separating seeds by type and size helps to optimize seed soil contact by controlling seed depth. Drill calibration provides accurate and uniform rates and distribution of seed, resulting in uniform rows. Greenscape drills includes a cultipacker, which rolls over the newly planted seeds and improves seed-to-soil contact. Its incorporation into the drill helps eliminate this extra step and decreases the amount of labor expended on each project.

Grass species with fluffy/chaffy seed, such as little bluestem, broomsedge, Indiangrass, and big bluestem, require seed drills with specialized seed hoppers. Some seed growers remove - or debeard - the fluffy awns on a seed that make them chaffy. When seeding debearded seed using conventional grass hoppers, the seed may still bridge above openings and clog the drill's tubes. Therefore, it is important to monitor the seeding operation. However, if debearded seed is used in specialized native drill seed hoppers designed for fluffy seeds, the seed may flow faster than anticipated, posing problems when calibrating for low seeding rates. It is advisable to calibrate seeding equipment using a sample of the actual seed purchased along with any carrier planned for use. Mixing with a carrier can be used to help obtain better distribution of small seeded species.

Seed Carriers

Because seed drills require calibration to achieve optimal seeding rates, placing seed alone in the hoppers will make it difficult to control distribution rates. Variance in seed size, weight, and shape can prevent uniform distribution rates. In such cases, it is best to use a seed carrier.

A good carrier adds weight, increases bulk density, and separates the seed, making it flow in a more predictable and manageable manner. Carriers are typically inert material that can easily pass through the drills blades and tubing. Common seed carriers include rice hulls, cracked grain, dry coarse washed sand, pelleted or granulated lime, soybean meal, hard seeds such as wheat, dry screened sawdust, or clay-based cat litter. Any carrier should be dry and flowable to insure that it passes easily through the equipment and it does not moisten the seed. The weight and hardness of a carrier can help keep drill boots free of bulky seed trash.

Desirable features in native grass drills:

■ Seed hoppers for fluffy/chaffy seed, small grain seeds, and legumes.

■ Chaffy seed boxes with seed agitators and picker wheel feed

■ Large, wide, straight drop tubes – 2” minimum diameter – from the chaffy box to the row openers

■ Double disc row openers with removable/adjustable depth bands used for depth control

■ Convenient, user-friendly calibration and depth control systems

■ Adjustable pressure packer wheels for closing seed furrow

■ Sturdy, heavy frame

■ Built-in cultipacker

■ Brackets to add weights for penetrating firm soil

Seed drills require proper training. Read the manufacturer’s manual or receive training from someone well-trained in use and calibration. Information from this manual alone is not sufficient to use seed drills. Rather, this manual provides guidelines and methods to optimize seed drill usage when planting native plant communities.

- Plant only when the soil is dry enough to prevent seeds from sticking to the coulters, the cutting blades that make the furrows in the soil for the seed. Under wet conditions, small seed will stick to mud-caked parts of the drill, rather than the ground.

- Keep seed separated by species until ready to plant. Prior to planting, organize seed into batches of large smooth seeds, small smooth seeds, and fluffy/chaffy seeds that do not flow easily. Loosely fill – *do not compact* – seed boxes with the appropriate seed batch for each box. If seed quantities do not cover the agitator, it is best to use a seed carrier to insure proper distribution since seed drills are difficult to calibrate for small volumes of seed.
- As a general rule, the planting depth for a particular seed should be no more than 1.5 time its diameter. To achieve this for most forb seed, set the depth controls to plant no deeper than ¼ inch. For best results, consult with the seed vendor for specific guidelines for seed depth calibration, especially on very sandy soils.
- Extremely small seeds, such as those for purple love grass, blue lobelia, or rushes, should be planted on the soil surface. Stop periodically to check planting depth by placing a ruler into the groove created by the coulter. The depth should not exceed ¼ inch. Such tiny seeds often tend to flow quite rapidly, disbursing fully before the whole field of planting has been covered by the seed drill. In addition, the agitation from the machine frequently will sift and separate these smaller seed to the bottom of a seed mix. If the seed drill does not appear able to properly distribute extremely small seed, combine the seed with a carrier, such as fine, dry sand and to hand broadcast the seed. Because the seed is so small and only requires surface planting, the weight of the seed carrier will be enough to insure proper soil contact.

Drill Seeding Tips

- Do not plant native seed deeper than ¼ inch. Most native seed is relatively small and lacks the energy to emerge if planted too deep.

- When calibrating the drill, it might be safer to set the rate a little lighter than the rate desired. Bouncing over the ground, a drill set at 6.5 lb. to the acre might actually seed 8 lbs. to the acre.
- For uniform coverage, it is best to drill seed at a lighter rate and go over the area two or three times. This will help insure that the seed does not run out before the job is completed.
- Multiple passes pack the seed well and create more rills that hold seed and interrupt water flow.
- The trash plow attachment on a native grass drill should just scratch the surface. If it's making furrows, it's planting too deep.

3.2.3.2 Hydroseeding

Pros:

- Hydromulch reduces soil erosion, especially on slopes
- Hydroseeding is ideal when bare, weed-free topsoil is used following new construction
- The risk of seeding too deep is decreased
- The colored mulch on the soil makes a positive impression on the public by indicating that revegation will soon occur

Cons:

- Mulch can be expensive, usually doubling the cost of a seeding
- Seeds may not have enough soil contact if the proper procedures are not followed
- The seeding rate can be hard to control
- Hydroseeding requires bare-ground application

Hydroseeding – one of the most commonly used methods for cool-season turf grass seeding – is a type of broadcast seeding that distributes seed, soil amendments, and mulch in a suspension of water. It is especially well-suited for steep (> 2:1) slopes or areas inaccessible for a seed drill or other mechanized equipment. Hydroseeding equipment uses a continuous agitation system that keeps all the materials in uniform suspension throughout the mixing and distribution cycles.

An integral part of hydroseeding is hydraulic mulch, which includes cellulose fiber (paper) mulch, wood fiber mulch, blended (cellulose and wood), or bonded fiber matrix, as well as stabilizing emulsion and tackifier, which help bind the mulch to the soil. Hydraulic mulch helps protect exposed soil from erosion by raindrop impact or wind.

Because native warm-season grasses and forbs require soil contact to germinate, the method required to hydroseed native plant seeds differs from the common method used when hydroseeding cool-season turf grass seed. Hydroseeding has become so common for cool-season turf grass establishment because it can be carried out in a one-step process. The seed, mulch, tackifiers, and water are all combined in the tank together and then sprayed as one layer of seed-infused mulch on the soil. During this process, the seed is suspended in the mulch and often does not have direct contact with the soil. In the case of cool-season turf grass, the lack of direct soil contact does not inhibit seed germination. However, if this method is used with warm-season grass, the vast majority of seed would not germinate because they would not have soil contact.

Hydroseeding is ideal for bridge approaches, cleanouts, culverts and wet or steep slopes. In most cases, the entire project can be hydroseeded from the shoulder.

Hydroseeding Warm Season Grasses

The most effective method for hydroseeding warm season grasses involves three separate steps:

- For the first pass of hydroseeding, mix and apply the seed, soil amendments and 5 to10 percent of the total fiber mulch with tackifier. This is especially effective on slopes because the tackifier helps bind the seed to the slope, thus preventing it from sliding down the incline. On flatter land, some advocate broadcasting the seed without the mulch to insure better soil contact.
- Improve seed to soil contact by incorporating the mixture with a cultipacker, roller, or bulldozer cleats.
- For the second pass, apply the balance of the mulch plus tackifier or bonded fiber matrixes.

Unlike the common one-step process used with cool-season turf grass, this three-step method insures that seed has good soil contact and is not suspended in the fiber mulch. To prevent clumping when using a hydraulic seeder, chaffy/fluffy seed that still have their awns attached, such as bluestems, indiangrass, or sideoats grama, should be added very slowly in small portions into the mix.

Fertilizer, Tank Agitators, and Seed Interaction

Seed left in the hydroseeder tank for periods of over one hour can be damaged by the fertilizer and tank agitator. Centrifugal pump agitation systems are more damaging than paddle systems. All wood fiber-based mulches need mechanical paddle agitated equipment, while cellulose mulch can be agitated with the centrifugal pump used for spraying.

It is best to spread lime prior to hydroseeding. Using the hydroseeder to apply the required amount of lime needed to amend the soil profile can do damage as a result of abrasion and settling. However, a *small* amount of specialized liming material is sometimes required to adjust the slurry pH when seeding legumes. It is advised not to use burnt or hydrated lime in the hydroseeder.

Hydroseeding Legumes

Legumes require species specific inoculation. When mixed with the hydroseeding slurry, the inoculant bacteria can be adversely affected by the chemicals included within the mix. Therefore, it is advisable to add the inoculant to the slurry just prior to spraying and add four times the rate of inoculants recommended when using a seed drill. As with all slope planting, the rate of legume seed should also be increased 20-25%. To improve the survival of the rhizobia bacteria and the subsequent ability of the hydroseeded legumes to fix nitrogen, add to the mix a small amount of hydroseeding liming product or pulverized limestone that has passed through at least a 200-mesh sieve.

Temporary Seeding

Native plant seeds, especially warm-season grasses, grow best when planted in a somewhat narrow window in the calendar year – usually late spring to early summer when the temperatures and moisture are high enough for germination and give the seedling roots time to establish enough to survive winter temperatures. Therefore, if a construction project ends before this time period and soil exposure is more than two months but less than 12 months, the best choice in such situation would be to establish temporary cover to provide short-term protection on disturbed areas. Temporary cover can come in form of cover crops, such as *Avena sativa* (grain

oats) from spring to August 1st or *Secale cereale* (grain rye) thereafter. If the topsoil at a construction site has a particularly dense weed seed bed, it may be best to plan for a series of cover crop plantings that will help to smother the germination of weed seeds. In such a scenario, start with buckwheat (*Fagopyrum esculentum*) followed by fall planting of cereal rye (*Secale cereal*) or winter wheat (*Triticum aestivum*). Buckwheat has the added advantage of providing pollinators rich forage. However, buckwheat should be mowed soon after flowering to prevent seed production.

When a temporary or permanent seeding cannot be completed in a timely manner, temporary cover can help stabilize the soil by applying mulch alone without the inclusion of seed. Under such circumstances, it is important to refer to the mulch manufacturer's literature for application rates and methods.

Hydroseeding Tips

- The usual one-pass application of hydromulch is ill-suited for native grass seeding. While such a technique saves time and effort, it will waste the seed and time used to apply it because it will prevent proper soil contact. The "three-step" method – seed applied first, cultipacking second, followed by hydromulching – results in better establishment.
- In an effort to conduct hydroseeding in one pass, some hydroseed practitioners have doubled the amount of seed they calculated they would normally would need. This increase in seeds would result in a greater amount of seed – to-soil contact. They estimate that the time and money saved on labor would pay for the extra seed.
- Seeding works best after it has rained, not just before. Seed and mulch adhere best on moist soils. This will also help capture moisture under the mulch. It is also important to

hydroseed several days before it again rains, thus allowing the mulch time to properly set before it rains.

- Seeding rates should be increased by at least 25% to compensate for seed damaged by hydroseeder mechanics and for seed that remains suspended in the mulch. This increase should be on top of the 20-25% increase for slopes. The steeper the slope, the greater should be the percent of seed increase within the mix.
- “Shadow areas” behind larger dirt clods sometime receive no seed from the hydromulch nozzle stream. To insure better coverage, conduct two passes, one from each direction. So as not to double the seeding rate, decrease the seeding rate to 7 to 8 mph, with flow rate reduced.
- An 800-gallon hydroseeder is the minimum recommended size. A 1,500-gallon hydroseeder can cover 1/3 acre per load. With a machine of this size, seven 50-lb. bales, or 350 lb. of mulch per load, yields about 1,000 lb. /acre.
- To prevent disturbance to newly seeded ground, start by seeding the area farthest from the road first.
- On steep slopes, embed the seed into the soil by holding the gun at a sharper angle and using a more concentrated stream.
- To reduce soil erosion, seedbeds can be left rougher.
- Steep slopes can be ripped with a wide-track dozer.
- Directional tracking – the process of creating ridges with tracked vehicles on unvegetated slope – scan be used to interrupt water flow.
- Work the site perpendicular to the slope to interrupt water flow.

Hydromulching rates:

• 1,000 lb./acre – a token amount to help carry the seed and show what area has been seeded

• 2,000 lb./acre – appropriate for most 3:1 slopes

• 3,000 lb./acre – very heavy rate for long, steep slopes

3.2.3.3 Sawdust as Seed Mulch

Pros

- Well-suited for use on narrow medians and below guardrails
- Does not required specialized training
- Helps suppress weeds that thrive on high levels of soil nitrogen
- Has shown greater rates of warm-season grass establishment
- Sawdust helps retain moisture

Cons

- Not enough testing with native cool-season grasses, such as *Deschampsia flexuosa*

Susan Barton, Associate Professor and Extension Specialist from the University of Delaware, has developed a method of native species establishment that uses sawdust as a medium for distributing seed mixes (pers. comm., January, 2015). This establishment method has proven effective because the sawdust appears to decrease the emergence of weeds while providing a mulch-like medium in which the native seed can set down roots.

This method can be used on vegetation-free topsoil following new construction or sites where vegetation existed but has been killed either using herbicides or non-herbicide methods. If

vegetation previously existed, mow the remaining vegetation to the shortest possible height available on the mower.

It is best to use decomposed sawdust for this application. Sawdust, which has high carbon content, breaks down rapidly and can rob the soil of nitrogen. While decomposed sawdust will still help to inhibit weed emergence, it will allow enough nitrogen to remain for successful warm-season grass seed germination.

The layer of sawdust should not be more than 1" deep. To calculate the amount of sawdust required to cover the area 1" deep:

1. Measure the square footage of the area to be planted.
2. Multiply the square footage by 1/12 of a cubic foot.

FOR EXAMPLE: 1000 SQ. FT. X 1/12 CUBIC FEET =

1000/12 CUBIC FEET OR 83 1/3 CUBIC FEET OR 9 ¼ CUBIC YARDS OF SAWDUST

Calculate the amount of seed required for the area to be planted.

Next, thoroughly combine the seed mix with the sawdust. The technique used to combine the seed and sawdust will depend on the size of the area to be planted, the equipment available for mixing, and the site where the mixing will take place.

For **larger sites**, there are two methods that can be used – one **off-site** and one **on-site**.

Off-site: This technique requires using the bucket of a front-end tractor loader to mix. On a flat concrete pad, dump the sawdust from a truck tailgate in stages. After dumping a portion of the saw dust, rack in an equal portion of the seed mix. Continue to dump and mix equal portions of sawdust and seed until the two quantities are combined. Use the bucket of the front loader to mix

the sawdust/seed until it appears well combined. Load the seed filled sawdust onto a truck to be transported to the planting site.

On-site: This technique involves mixing the seed into the sawdust as the sawdust is being unloaded at the planting site. If the truck delivering the sawdust has a dumping bed and does not weigh so much as to create deep tire tracks, have the driver dump the sawdust in small piles as the truck moves forward. If the truck is too heavy or too large to access the site, have workers unload the sawdust using wheelbarrows. Evenly sprinkle the seed on top of the sawdust piles and combine the seed into the sawdust while racking the sawdust evenly over the site. Using a water-filled turf grass roller or cultipacker over the layer of sawdust helps insure better root soil penetration.

(Sidebar: Sawdust as Planting Medium for Seed – See Appendix F, pp.103-104)

3.2.3.4 Broadcast Seeding

Pros

- Inexpensive
- Easy to carry out
- Well suited for smaller areas
- Prevents finer-seeded species from getting buried under too much soil
- More compact than a drill and easier to get in and out of ditches
- Can be backed up to silt fences to sling seed on both sides.
- Many models and sizes of broadcasters currently exist, including hand-held crank and larger tractor or ATV-mounted models
- Many state agencies and subcontractors already own broadcasting equipment

Cons

- Requires a smooth seed bed or one where the stubble has been closely scaled
- Requires the added step of pressing the seed into the soil after planting
- Difficult to calibrate when using seed other than that for cool-season turf grass
- Hard to carry out using fluffy/chaffy seed
- Some broadcast seeder models cannot accommodate large seeds

Broadcast seeding works best when seed can readily reach the soil surface, uninterrupted by existing vegetation. If the topsoil is not exposed, remove as much stubble as possible prior to seeding, creating a smooth, lightly-packed seedbed. While the soil surface can be lightly hand-raked or harrowed to break-up crusted surfaces, avoid cultivating the site. The greater the disturbance, the more likely weeds will be exposed to light and moisture, thus leading to their germination.

Broadcast seeding results in greater variability of seed depth compared to seed drilling. Due to this variability, it is important when broadcasting to increase seeding rates by 25 percent relative to those used when drill seeding. When broadcasting with little seedbed preparation and limited ability to track the seed if no inert carrier is included in the mix, increase seeding rates by 50 to 75 percent. This increase helps to compensate for the inability of seed to germinate as a result of poor soil contact or the loss of seed to predators.

If the landscape varies in terms of light, soil type, or sloping, manual broadcast seeding does offer the opportunity to spot-seed microsites using different seeding rates and seed mixes.

With the development of commercially available techniques for producing cleaner, less fluffy native seed, broadcast seeding has become a more viable seeding option. Debearded seed flows

better and slings farther than in the past when applied with broadcast seeding equipment. However, if the seed is not debearded, broadcast seeding has some limits. Inert carrier ingredients, such as dry sand, rice, rice hulls, fine-grained vermiculite, clay-based kitty litter, gypsum, fine cornmeal polenta, or dry flowable sawdust may help to condense the chaff of native seed enough to allow it to pass through some broadcast mechanics. Conventional spinner-type pendulum spreaders may work best since they have large enough openings to prevent clogging as a result of the fluffy chaff.

Inert carriers can also help with machine calibration, especially when seed quantities are small. Use two to three parts inert carriers for each part seed by volume. These bulking agents also ensure even seed distribution and visual feedback as to where seed has been thrown.

Since smaller seeds will tend to sift down to the bottom of a mix when combined with larger seeds, it is best to plant smaller and larger seeds separately to insure even distribution. The most effective broadcast seeding equipment has an internal agitator and flow gate opening able to be closed small enough to provide a slow, steady flow of the smallest seed. Begin planting the smaller seed with the flow gate set to the narrowest opening, thus allowing at least two perpendicular passes over the seed bed for even distribution. Plant very large seed separately with the flow gate set to a wider opening.

For smaller sites less than one to two acres, seed can also be hand broadcast. To insure even seed distribution, bulk the seed mix with an inert carrier, divide the seed into at least two batches, and sow each batch separately. Walking in perpendicular passes across the site, scatter the first batch evenly over the site, walking back and forth following the same direction. Then scatter the second batch by walking in passes perpendicular to the previous passes.

Regardless of the manner in which the seed is broadcast, avoid covering the seed with soil after planting. Use a water-filled turf grass roller or a cultipacker to press the seed into the soil surface. Natural precipitation or light overhead irrigation also can help ensure good seed-to-soil contact.

(Sidebar: Coated Fluffy Seeds – See Appendix E, p.105)

3.2.4 Cover Crops, Nurse Crops, and Companion Plants

Cover crops are divided into two classifications:

1) Nurse crops or companion crops, which are planted along with the permanent seed mix.
2) Temporary seedings or stabilizer crops, which are planted by themselves pending a better time to plant the permanent mix or to smother weeds as part of site preparation.

Nurse crops help reduce weed pressure, prevent erosion, and prevent excessive sunlight from reaching tender seedlings. However, if allowed to grow too tall – as often happens with cereal rye (*Secale cereal*) – some nursing crops can shade native seedlings. Therefore, mow nursing crops to 6 inches once they start to exceed 8 inches.

Cover crops used as stabilizing placeholders are recommended on slopes 3:1 or greater. Oats (*Avena sativa*), annual rye (*Lolium multiflorum*) and winter wheat (*Triticum aestivum*) work especially well as cover crops; they are inexpensive, establish easily, and do not outcompete the native perennial species.

(See Appendix I: Recommended Nurse Crops/Companion Crops, pp. 109-110)
(See Appendix J: Profiles of Cover Crops, pp. 111-114)

3.2.5 Mulching

While plants ultimately provide site stabilization, mulch initially plays several roles in the establishment of native plant communities:

- Prevent seed predation by birds and other consumers
- Provide temporary erosion control until seedings establish
- Maintain soil moisture to aid seed germination and plant survival
- Reduce weed pressure
- Moderate soil surface temperature fluctuations
- Reduce frost heaving
- Add organic matter
- Improve water infiltration by reducing surface compaction or crusting
- Provide temporary erosion control when waiting for the proper planting dates for permanent seeding

Like vegetation, mulch prevents erosion by protecting the surface from raindrop impact and by reducing the velocity of overland flow. Apply mulch to a density that protects the soil from erosion while providing enough water and light penetration to allow seedlings to emerge.

Common mulching practices work well in aiding the establishment of cool-season grasses in the spring and fall by keeping seeds and soils moist and their temperatures well-modulated. However, native warm season grass and some native forbs seeds have evolved to germinate under the warmer conditions of late spring and early summer. Thus, if improperly applied, mulches can delay and prolong their germination, thus increasing the risk of failure. When using

mulch for warm-season grasses and forbs, reduce rates to 1,000 pounds per acre to allow sunlight penetration to the soil surface.

(See Appendix K: Types of Mulch, pp. 115-119)

3.3 Post-Establishment Monitoring and Maintenance

Monitoring during the first year

One of the biggest challenges encountered when transitioning to native roadside vegetation involves changing the expectations of what constitutes successful establishment. The manner by which bio-diverse native plant communities establish differs greatly from the manner by which cool-season turf grasses establish.

Cool-season sod-forming grasses germinate and grow relatively quickly. Small green seedlings quickly sprout all over the field and grow to relatively uniform heights, resulting in a field with an even, clean appearance. Within several weeks, if successfully established, turf has the appearance of a green carpeting. By the end of the first growing season, turf has developed. On the other hand, native plant communities consisting of warm-season grasses and perennial forbs usually take three to five years to establish. Not only is the growth process slower than for turf, but it takes several years for practitioners to learn the skill set required to establish, evaluate, and maintain successful stand development.

First-year native seedlings are small and grow more sparsely and less uniformly than turf seedlings. As a result, people often worry or assume their plantings have failed. While the aboveground growth of newly planted, warm-season grasses may appear subpar, in fact native warm-season grasses during their first year put most of their energy into developing extensive

root systems. Leaf and stem growth rarely reach more than one foot high by the end of the first growing season. In many cases, relatively little flowering occurs the first year. Not until the second growing season does considerable aboveground biomass develop, finally resulting in grasses flowering and producing seed. If seedling density appears sparse, don't panic. An adequate, mature stand of native warm-season grass might have as few as one plant per square foot. Individual plants grow quite large, and may fill in poor stands by self-seeding or spreading vegetatively. A mature little bluestem clump eventually can measure one foot in diameter.

It is not uncommon for first-time growers of native plant communities to think their planting efforts were a waste of time. During the first year, the field is usually not pretty or uniform or green all over – as we have all come to expect with turf grass. Expect quite a bit of undesirable weeds growing among fields of desirable native seedlings.

Because native seedlings frequently grow among weed seedlings, expect in the first few years the need to develop the ability to distinguish weed seedlings from desirable native seedlings. People unfamiliar with native warm-season grass seedlings often conclude a planting has failed because they have not yet developed the ability to properly identify and distinguish between the various species within a planting. This is especially true when seeds are broadcast rather than planted with a no-till drill, which creates rows of plants that help guide the eye to where the new seedlings will appear. One approach helpful in identifying native seedlings involves digging up a few new seedlings and looking at the attached seed. This requires creating a chart of the seeds that were included in the original mix.

Most native warm-season grass seedlings look like small fountains (Include picture) and, on average, do not grow closely together. Frequently during the first growing season dicot seedlings are mistakenly identified as weeds when, in fact, they are actually desirable, perennial forbs,

which often only grow rosettes their first year. Many perennial plants take two or even three years before they flower. However, some seedlings in fact may be undesirable and need to be removed before they flower and add to the field's seedbank.

Tips for Monitoring and Evaluating New Planting

- Inspect the seeding at least three weeks following the seeding.
- Evaluate weed pressure. If heavy, plan and implement all necessary weed control treatments. The degree and rate of success of any seeding project will depend on weed control during the establishment period.
- Make additional inspections:
    - Following major rain events or for areas with expected high velocity and volumes of concentrated water.
    - On steep slopes.
- Where erosion is evident, repair areas by reseeding and mulching.
- If erosion control matting exhibits significant movement, reinstall and staple as needed.
- If the site was drill-seeded, examine the rows and look for a pattern of similar seedlings. This helps develop an eye for distinguishing between desirable and undesirable seedlings.
- Use seedling ID books or take a computer tablet to the field and use the plant profiles in this manual. Have a list of what was planted and find seedlings pictures for the species included in the mix.
- If uncertain about the success of a planting, consult a botanist for help identifying seedlings.
- Unless heavy rains wash away a planting, allow two full growing seasons before giving up and starting over.

Weed control and establishment mowing

Because native warm-season grass seedlings initially grow slowly, competition from grass and broad-leaf weeds can be severe. Weed control must take priority. The three basic methods for controlling weeds in new establishments are:

1) Mowing
2) Digging and pulling weeds
3) Spot treatment using selective herbicides
4) Flame Guns for Spot Weeding

Mowing

Mowing helps control weeds by:

1. Controlling annual and biennial weeds during the first two years after seeding
2. Controlling cool season grasses and weeds during the third year of establishment
3. Helping prevent tree and shrub encroachment

When choosing mowing equipment, consider both the terrain on which the planting occurred and the height of the mowing. Mowing for weed control is conducted at heights higher than those used for turf mowing. Generally, turf is mowed at heights ranging from 1”-4”. Native plant stands, on the other hand, require heights ranging from 6” to 12” during the first two years of establishment. Therefore, while heavy duty riding lawnmowers, wheeled brush mowers, string trimmers, and tractor-mounted mowers can all be used for weed control mowing, the equipment must be able to be adjusted to the right height for each circumstance. String trimmers work best

in many situations – for small areas, for spot weeding, and where other equipment cannot go, such as steep slopes and low wet areas. In addition, they can mow at a variety of heights and, unlike many mowers, they lay down the cut material gently without clumping, which can suffocate seedlings.

First Year: Mow weeds to a height of 6" early in the first year and at 12" later in the year if the native grasses grow higher than six inches tall. Mow just above the tops of the native grasses. This prevents weeds from shading the shorter grass seedlings and setting seed, thus reducing weed pressure in following years. Expect to mow two to three times in the first year. Do not allow the weeds to grow over 12 inches tall before mowing, otherwise the mowed material can smother the small seedlings.

Second Year: Mow annual and biennial weeds in mid to late June at a height of 12 inches to prevent annual and biennial weeds from forming seeds. Many native grasses begin growing vigorously during the second growing season. If weeds continue to cause a problem later in the second year, mow again just above the tops of the warm season grasses. Since many warm-season grasses start to flower and set seed the second year, it is important not to mow off their flowers before their seeds have ripened. Flail type mower work best in these situations because they chop the material, allowing it to dry rapidly without smothering the smaller grass seedlings below. Rotary mowers usually leave the cuttings in piles, which create a thick mat of clippings that can smother the young native plants.

Third Year and Beyond: One of the most effective methods for controlling weed during the third year of native prairie establishment in the Midwest is the use of prescribed fire in the Spring. Since prescribe fire would create safety issues for New England roadsides, mowing must be conducted in a way that would best mimics how prescribed burning works. Since prescribe

burning works by removing dead plant growth from the previous year, mow in the spring and rake off the cut material, which helps expose the soil and accelerates soil warming, which favors warm-season grasses and forbs. Mow as close to the ground as possible, right down to the soil surface if possible. This achieves an effect similar to burning by giving warm-season native plants an advantage over cool season weeds and grasses.

Timing of Spring Mowing

The best time to spring mow a native plant stand varies from year to year. For controlling cool season grasses and weeds, the best time is mid-spring, usually between April 15 and May 15, although this period will vary based upon latitude and the weather in any given year. A good indicator for when to spring mow is the buds of the sugar maple (*Acer saccharum*) just start to open in spring. This corresponds to the time when warm-season native herbaceous plant species are also just beginning to emerge from winter dormancy. Since these plants have grown little by this point, they remain unharmed following mowing.

To control woody plant encroachment, a late spring mowing will inflict more damage to them than a mid-spring mowing. Mow once all trees and shrubs have fully leafed out, which generally occurs in mid to late May. Although grasses and forbs plants will suffer slightly from such a close mowing at this time, a late mowing will severely damage most woody plants. The herbaceous plants will grow back rapidly, but the woody plants will recover more slowly.

Digging and Pulling of Weeds

Problem weeds, especially those with taproots, can be carefully pulled or dug beginning in the second growing season. Pulling and digging is not recommended in the first year of establishment because the small native seedlings, which have not yet rooted well, can be easily

disturbed and killed. By the second year, biennial and perennial weeds that have established will be evident. For biennial weeds, carefully pull the plant, or cut at their base during flowering to kill them. Remove plants prior to setting seed to prevent re-infestation in future years.

When pulling weeds that have taproots, hold the weed firmly between the feet and pull straight up. This holds the soil in place around the roots, and minimizes disturbance to adjacent young native grasses and forbs. Firmly tamp down any loose soil back into place around desirable plants that may have been disturbed. Weed pulling is easiest just after rain has moistened the soil. Pulling weeds from dry soil usually results in broken off roots that will re-grow and require future attention.

Spot treatment using selective herbicides

It is never recommended to *spray* glyphosate-based herbicide, such as RoundUp in a native plant stand since, as a broad spectrum systemic herbicide, its drift will kill the surrounding desirable plants. An alternative approach to spot-treat specific plants with Roundup or a specific selective herbicide using something termed the “Glove of Death” or “Tongs of Death.” These involve soaking an absorbent material with an appropriate herbicide and carefully targeting undesirable plants, thus preventing drift from killing neighboring desirable plants.

To conduct either of these techniques, first protect your arms and hands with heavy-duty, long, rubber herbicide application gloves. For the “Glove of Death” method, place a larger size, absorbent cotton glove over the herbicide glove on one hand. Soak the glove with herbicide by moistening it using a small sprayer bottle set on “stream” rather than “mist.” Soak the glove until saturated, but not dripping with the herbicide. Then wipe the glove on the target plants, making

sure to uniformly apply the herbicide to the leaves. To prevent damaging nearby desirable vegetation, move them to the side with your feet or the hand without the herbicide glove.

The “Tongs of Death” utilizes the same technique, except the end of a set of tongs gets wrapped in old cotton socks or other absorbent material. Apply herbicide to the tongs from a bucket, or by spraying from a bottle, as with the “Glove of Death” method.

For both techniques, it might be advisable to use a spray bottle along with an empty bucket. Spray the absorbent material over the bucket so as to minimize drift. In addition, this technique may avoid unwanted spilling that could result if an open container of herbicide accidently tips over.

Controlling Broadleaved Weeds

Targeting broadleaved weeds using herbicides that kill only broadleaf plants will leave grasses unharmed. However, most broadleaf weed killers will also kill most desirable native forbs. Therefore, it is not recommended to spray a native plant establishment that includes both grasses and forbs with a broadleaf herbicide, since this will kill the native wildflowers. However, if using the two step process of establishing native grasses during one season and native forbs a following season, applying a broadleaf herbicide across an entire field to help increase the density of the grass stand before the forbs have been added is a an affordable and effective technique.

Inspection of Seeding

Stand Evaluation

Stand evaluation is conducted after all primary weed control measures have been implemented. Evaluate stands when seedlings are approximately 6 to 12 inches in height. For critical area seedings of introduced grasses and legumes on slopes of 5:1 or greater, a seedling density of 80 to100 seedlings per square foot is desirable. For conservation seedings on agricultural land where erosion control is a concern, a seedling density of 40 to 50 seedlings per square foot is desirable. For conservation plantings where erosion control is not the primary objective, 20 to 25 plants per square foot will satisfy most needs. Warm season grasses can tolerate less density although early density is important to compete with weeds. It is normal for stands to thin out during the establishment period and stands of 50 percent of the above densities are acceptable in the spring following seeding. Warm season grasses can obtain canopy closure after several years with as few as 2 seedlings per square foot if weeds are controlled. A less dense stand will lend itself to more species diversity, which is desirable for some conservation objectives. Although some of these species could be considered weeds with the potential to spread to other fields, it is important to carefully evaluate native seedings so that effective management decisions can be made. The use of point-intersect techniques or seedling counts per square foot using a grid system can aid in the systematic evaluation of plantings. For warm season grasses on soils with areas prone to frost heaving, evaluate again the following spring.

IV: Focus Groups of New England Departments of Transportation Managers to Identify Barriers to Implementation of New Revegetation Protocols

Part of this research involved conducting focus groups with managers from New England Departments of Transportations (DOTs) to determine the barriers that might impede successful transitioning from current roadside revegetation practices. Despite the ecological, environmental, and economic benefits native warm-season grasses (NWSGs) could provide New England and other state DOTs, few state DOTs have implemented successful NWSG establishment practices. Several barriers currently impede such adoption. First, few agencies understand that an alternative exists to traditional cool-season turf grasses. Secondly, cool-season grasses establish far more rapidly than NWSGs. Cool season grasses can take as little as four to six weeks to establish while NWSGs often take three to five seasons to establish a dense, stable stand. Although NWSGs require less long-term maintenance, their initial establishment is more labor and time intensive than cool-season grasses. Thirdly, change in maintenance practices requires DOT bureaucracies to adapt to new regimes. Such bureaucratic changes rarely come quickly or easily.

A manual providing instructions on how to establish NWSGs will be insufficient in and of itself to insure that new practices will be adopted. Thus, the goal of this study is to identify the roadblocks that might impede successful implementation of protocols for the establishment of native plant communities. This study used the focus group method as the means for interviewing participants and collecting information and data concerning the attitudes and opinions of state DOT managers on the possible barriers to implementation of new protocols for roadside revegetation.

4.1 Methods

It was determined that the focus group format would work best to elicit the most comprehensive set of data by fostering an interplay of group participant opinions, each representing the attitudes and opinions of his or her particular department (Barbour, 1999). The focus group format allowed for the widest range of participants from various departments, thus allowing questions to be answered most thoroughly and authoritatively. This method relies on a specific strand of interactionist theory; that is, the ”negotiated order” approach to the study of organizations developed by Anselm Strauss (1978), which emphasizes that ‘any change arising within or imposed on the order will require *renegotiation* to occur’ (Dingwall and Strong, 2011).

The interviews took place at DOT headquarters in each state. Each focus group included high-level managers from departments whose work involved aspects of roadside vegetation, including construction, engineering, landscape architecture, conservation, and maintenance. The groups ranged from five to eight participants and were conducted at a conference table in a conference room at the state’s DOT headquarters. Of the six New England states, five state DOTs availed themselves for focus groups: Connecticut, Rhode Island, Massachusetts, New Hampshire, and Maine.

The focus group interview process followed a semi-structured survey instrument (that is, a “script”) developed to determine the following aspects of NWSG establishment:

1. DOT worker familiarity with NWSGs
2. Existence of current programs for the establishment of NWSGs
3. The degree to which NWSG establishment practices resemble or differ from current re-vegetation practices
4. The openness and flexibility of DOT workers to adopt NWSG establishment practices

While each focus group followed the same script, information from former focus groups sometimes influenced the questions at later focus group interviews. Therefore, while each focus group was conducted as consistently as possible with repetitively posed questions and procedure, new questions were added as participants provided the researchers with new information with which to conduct their interviews and research.

Ethical Considerations

Participation in the focus group was voluntary. Before conducting the focus group, the participants were read an opening statement that explained the goals of the research project and the intent of the focus group. To encourage frank and honest participation, it was made clear that the participants' contributions would remain confidential, unless researchers specifically requested to reveal the source at a later time. The focus group was informed they would be recorded, their dialogued transcribed for analysis purposes and, if at any point, any participant felt uncomfortable with the process, he or she could simply not answer a question, refuse to participate, or ask for the recording to be stopped. The length of each focus group ranged from 70 to 100 minutes. Before conducting the focus groups, the script for the interviews was submitted to University of Connecticut Institutional Review Board (IRB) to assure that the inquiry of "human subjects is conducted in accordance with legal requirements and ethical principles of Respect for Persons, Beneficence and Justice." Since the nature of the questions were not personal, the board waived the need for official IRB review.

4.2 Results and Findings

The focus groups revealed several challenges that need to be addressed to insure a successful transition to NWSG establishment practices:

- Motivating each DOT
- Addressing structural impediments within DOT
- Addressing outside structural impediments
- Addressing funding issues

4.2.1 Motivating DOT Managers

1. Stressing that Native Grass Establishment is Tied to a Federal Mandate

To address the topic of how best to motivate DOT workers to implement new policies, it would help to turn to the way one focus group participant answered this question: *"On a scale of 1 to 5 – How flexible, willing, and able do you believe your DOT has been at adopting new practices in the past?*

To which a participant asked, *"If there's a regulation behind it?"*

When told yes, the participant answered, *"Four. If no regulation, 1."*

This answer succinctly captured what several participants stressed repeatedly: the best motivation for changing policy is simply to make it a requirement and each department will do whatever is necessary to implement that new policy. Whether or not a department wants to or believes it necessary to change a policy, if that department is required, it will make the change.

If the best motivation comes in the form of directives sent from upper management, the next step requires:

2. Getting Buy-in from Upper Management

Implementation of these policies would likely gain traction if upper management in each state DOT either felt a pressing urgency or non-negotiable mandate to do so. Focus group questions explored which departments seemed most likely to act as drivers to insure adoption of these policies. Interviewees asserted consistently that the landscape design departments within the DOTs to be most critical for the adoption of any new practices. They believe this is because landscape design departments typically write the re-vegetation specifications contained in construction contracts.

The next most critical department for new practice adoption as asserted by interviewees was maintenance. This is because decreased mowing regimens would help them tend to other responsibilities. Several department heads from each state participate on the board of the New England Transportation Consortium (NETC), which commissioned this study. Their buy-in could go a long way in helping to persuade each state DOT to take the necessary steps to change policies.

However, if the greatest catalyst for policy change comes simply in the form of new regulations, it should be made clear to upper management of each state that this transition to new roadside NWSG establishment practices is not optional but rather mandated by the federal government.

3. Cost-Benefit Analysis

While mandates and new regulations most effectively catalyze bureaucratic policy change, persuasive cost-benefit analysis can go a long way in easing the transition from a familiar, long-practiced policy to a new, unfamiliar one. During every focus group, at least

one participant made the point that management wants to know that a new method can save either money or time, or better achieve a particular objective. One DOT member discussed a meeting where he had to find methods for drastically cutting fuel consumption by department vehicles and equipment for both budgetary and environmental reasons. The fact that one of the main objectives of NWSG establishment is the reduction of mowing regimens to once or twice a year can go a long way to achieve such a goal. When participants heard of other benefits provided by NWSGs better erosion and stormwater control as a result of deeper roots, ecological restoration for native biological populations, increased biodiversity, increased flowering for native pollinators, and a bulwark against invasive species they expressed a greater openness and willingness to change policies.

While recitation of the qualitative benefits of NWSG did much to win over DOT managers to the efficacy of such a policy change, an even more persuasive approach would come in the form of a quantitative economic calculation that would come with NWSG establishment. Just such an economic impact statement (EIS) can be commissioned through such organizations as Earth Economics, a Seattle-based non-profit group that calculates the economic and ecological costs and benefits of projects to ecosystem.

4. <u>Educational Program</u>

Any change in policy would require a program to educate workers about the differences between NWSGs and cool-season grasses. Preliminary focus group questions found most participants had a vague understanding of the differences between the two kinds of grasses, but few participants, other than about three or four landscape designers from different states, could talk about them authoritatively. It is not important that few managers can distinguish between the paths by which these two categories of grasses carry out photosynthesis.

However, making such a significant change in the roadside vegetation management protocols requires justification for transitioning from one set of plant species to another. It became clear that to get buy-in from DOT workers required development of a program that would educate workers about the biological differences between NWSGs and cool-season grasses and the ecological, environmental, and economic benefits of using NWSGs. Participants repeatedly stressed the necessity of this step in any transition to a new policy.

5. Proven Establishment Strategies as Demonstrated through Successful Projects

Several participants voiced the need to see evidence of the effectiveness of any NWSG establishment protocols. Each state may want to conduct preliminary trials to act as both labs for their own efforts and to provide easily accessible evidence (demonstration plots) of the effectiveness of the establishment protocols. Considering that one of the drawbacks of NWSG establishment is the longer time it takes for NWSGs to establish compared to cool-season grasses, it is advisable that such test/demonstration plots be one of the first steps that each state DOT undertake during their transition. Each DOT might consider starting trial programs that explores and documents these new vegetation protocols. Concurrently, DOT can start putting in place other facets of the transition, such as those portions dealing with policy changes and education about the new protocols.

An example of a new effective and affordable revegetation practice DOTs can begin to implement and our research revealed shows significant results within one growing season is a technique we term *augmentation of existing native plant communities*, which increases the density of pre-existing NWSG colonies. This process works as follows: first, locate a stand of NWSG, whether little bluestem or broomsedge. The best time of year to do this is usually toward the end of August when purple lovegrass is in bloom. It is often easier to identify

grasses by the morphological structure of their flowers than that of their leaves. However, if maintenance has mowed stands, a qualified botanist may be able to help locate a colony during other times of the year. Then, having located the stand, cordon off a portion of the grass population and, during the period from the beginning to the middle of May, spray the cordoned off portion with an appropriate herbicide, such as glyphosate or Plateau. This will kill off the cool season grasses, weeds, and invasive species but leave unaffected warm-season plants that have yet to emerge. By killing off the cool-season plant competition, the NWSGs flourish and develop more dense colonies. This same technique can be practiced in fall but only with Plateau, which kills off cool-season plants but leaves NWSGs and many native forbs unaffected.

6. Tying establishment of NWSGs to Elimination of Invasive Species

At least two focus group participants suggested that tying the establishment of NWSG to the elimination of invasive species would help make this policy change more attractive to management. After eradicating invasive species, these members suggested that cleared land be re-vegetated with NWSGs and forbs. The newly planted native plants can possibly help prevent the re-encroachment of invasive species.

4.2.2 Addressing Structural Impediments within DOT

1. Reformulating the Re-vegetation Contracting System Following New Construction

A major structural challenge that will need to be addressed when transitioning from cool-season to warm-season grass establishment is the existing contracting system for re-vegetation following new construction.

Currently, all New England state DOTs sub-contracting re-vegetation after new construction to private companies. Most contracts for each state for grass establishment follow similar frameworks: the contractor receives half their payment for services at the start of the grass establishment process. Only after a set period of time (usually several months) the contractor will receive the second half of their payment once the plot for which they were contracted to establish grass has shown satisfactory growth. Considering the relatively short period of time it takes for cool-season turf grass to germinate (usually several weeks to months) such a system has proven workable for both the DOT and the contractors. However, since the time frame for NWSG establishment can span several growing seasons, such a payment structure and system of accountability may no longer be viable. Formulating a new framework is not immediately apparent and each state may need to develop ones that best suit their states.

Some participants insisted that the only way to insure long-term accountability for proper germination would be moving the process back in-house and have it carried out by each state's maintenance department. Such an approach has several advantages. First, NWSG establishment often requires follow-up during the first few weeks after initial seeding to inspect for and possibly treat any encroaching weeds that may outcompete the NWSG during the establishment period. Since DOT maintenance departments will be discouraged from mowing between mid-May to mid-March, maintenance workers could use the time freed from mowing to inspect

NWSG establishment progress. In addition, by moving re-vegetation back in-house, funds that had previously left the department can remain internally, helping to bolster a department that, according to several participants, is often the first victim of budget cuts.

Whether or not the process remains privatized or moves in-house, the process of NWSG establishment requires specialized knowledge that will almost certainly require trained individuals, certified in newly developed programs by each state under guidelines similar to those used to certify pesticide applicators, arborists, and turf and ornamental shrub specialists. To receive certification, applicants would need to understand the differences between cool- and warm-season grasses, learn to visually identify and distinguish between common roadside native and non-native species, properly apply herbicides at the appropriate times in the growing season, become familiar with the different methods available for NWSG establishment, and develop the ability to scout for pre-existing NWSG populations to perform population augmentation. Such certified individuals could act as lead managers on NWSG establishment.

Another complexity that needs consideration is optimal timing for NWSG establishment. Under the current system, cool-season grass seeding occurs immediately after construction ends. While spring and fall are the optimal times for cool-season grass germination, in reality seeding for turf grass can take place during almost any part of the year except in the middle of winter. Considering the possibility of erosion from bare soil, this flexible establishment schedule has served DOTs well.

Optimal NWSG establishment does not allow for such flexibility. Research has found the window during which NWSG establishes most successfully ranges from late spring to early summer. Some techniques point to the possibility of successful dormant seeding in late fall. Unfortunately, construction project termination dates do not always coincide with optimal

NWSG establishment periods. As such, another establishment formulation would need to accommodate year-round construction.

One participant suggested the following solution: plant cheap placeholder or cover crop as erosion control and then return in late spring and properly establish the NWSG during their optimal growing period. Either an in-house crew or private contractor could return to establish several plots previously seeded with cover crops to control erosion temporarily. By using a cheaper initial erosion control mix, a portion of the re-vegetation budget can be saved for the later NWSG establishment, thereby only slightly increasing the amount of money required to seed twice. It is an imperfect solution and probably needs more logistical tinkering, but it points to the possibility of resolving one of the main problems for which this research project was funded: the difficulty in establishing NWSGs. However, while the upfront costs and efforts needed to establish NWSG may appear slightly more complicated and costly compared to those required for cool-season grasses, once established the costs and efforts decrease while the benefits increase.

2. Development of Consultant and Management Positions

Delivery of a manual with techniques for NWSG establishment in and of itself probably would not be sufficient to instigate the changes needed to transition to new roadside vegetation policies. Other state DOTs, such as Delaware's, have made similar efforts to change policies, going so far as publishing two well-regarded manuals (Barton 2005, 2009), but have experienced a slow process of transitioning (Barton 2014). What other states have done that have successfully transitioned to new protocols, such as Iowa on the county-level, was develop a position for someone who could lead these new efforts. Specifically, Iowa counties created a full-time

Roadside Manager position familiar with these new protocols and able to guide roadside managers and their departments during the transitional process (Brandt 2015).

Originally, the position our team envisioned was a consultant shared by several New England states, who would travel from state to state and advise on new establishment projects. NETC would fund the position, with several states pooling funds together to pay for the consultant's services. However, in the course of the focus groups, several participants envisioned a more expansive role for the consultant. During the first few years of transitioning to new policy, the consultant would work with each DOT and develop educational and training programs related to the new policies and would help reformulate maintenance practices to insure the proper establishment of these new native plant communities. In essence, the consultant would act as a driver within each DOT, insuring the implementation of new policy. This feedback made our team rethink the nature of a consultant position. Eventually we came to believe that the more effective way for each state to commit to new protocols would involve making the consultant position transitional and creating a permanent Roadside Native Vegetation Manager position for each state. The savings that would result from effective protocol implementation would help offset the cost for each state of developing this new position.

3. Gradual Implementation of Program

Considering the fact that this transition in establishment practices will change decades old policies, expecting changes to happen overnight would be unrealistic. A realistic, gradual, yet firm implementation of the program over several years will insure a successful change in policies.

Cool-season grasses cannot be maintained the same way as NWSGs and vice versa. Although mowing cool-season grasses once or twice a year in spring would help transition their populations to warm-season populations, they would look unkempt in the process, leading to increased driver complaints. Mowing NWSGs too often, too late in the season or too low would decrease their viability.

A preliminary set of goals over a number of years require development. Goals would include planting trial plots, educating DOT workers concerning the changes in policies, mapping NWSG populations, developing NWSG establishment certification programs, changing maintenance department mowing regimens, developing funding sources for the new policies, etc. Considering the longer gestation period required for NWSGs, a time frame of several years would suit the establishment length of the crops involved.

4.2.3 Addressing Funding Issues

The theme most often raised in the course of focus group discussions concerned the need for money to fund any new efforts. Money would be needed for labor, equipment, maintenance, supplies, and plant material. It seemed that every department within each DOT was stretched thin financially, especially maintenance. Lack of any new money to fund work beyond that which already was taking place limited the scope of any new projects. Therefore, finding funding became paramount.

1. <u>Funding within the department</u>

The possibility existed that funding might come from savings derived as a result of new practices. Decreased mowing regimens would mean decreased use of fuel and wear on

equipment. Such savings could shift toward establishment practices. Similarly, moving re-vegetation in-house may reduce the costs for each establishment project.

2. Finding federal programs for the elimination of invasive species and the establishment of native grasses

Since these directives derive from mandates related to invasive species elimination, the possibility exists that federal funding can help supplement each state's requirement to meet such mandates. However, more direct funding from the federal government came into existence since we conducted these focus groups: on December 4, 2015, President Obama signed into law the Fixing America's Surface Transportation (FAST) Act (Pub. L. No. 114-94). Sections 319 and 329 of this bill allows states to allocate portions of their block grants to fund the establishment of pollinator habitats using native plant species when revegetating roadsides following new construction. Appropriating these funds requires each state DOT be familiar that this provision exists and that someone within that DOT act as an advocate to secure funds for this specific purpose.

3. Reach out to the private sector

Some participants suggested turning to the private sector since they remain far more flush financially than the public sector. An urban beekeeper in Boston recommended adapting the Adopt-a-Highway model as a means for financing the establishment of pollinator habitats along portions of the roadside (Wilson-Rich 2015). He even offered his non-profit organization free of charge to run such a program. All he asked was that he and other scientists involve in pollinator health research have access to these new sites to study their effectiveness in increasing pollinator populations and general health.

4. Finding non-profit funding for pilot programs

Finding funding from non-profit groups in the form of grants to fund pilot programs seemed like one of the more promising suggestions provided by the focus groups.

4.2.4 Other Hurdles

1. Securing wide-spread access to no-till drills

No-ill seed drills, such as those manufactured by the Truax Company, are some of the most effective pieces of equipment for seeding native plant communities. No-till drills use blades called coulters to slice shallow groves into soil beneath dead plant residue, into which tubes plant native seed at the proper soil depth. One of the biggest advantages of these drills is their ability to effectively make contact between the soil and NWSG seeds, which have fluffy awns that often make soil contact difficult to achieve. In addition, these drills minimally disrupt the soil, thus avoiding disturbance of weed seed banks, and preventing weed germination and the competition that comes with such germination.

Currently, only Connecticut and Rhode Island have easy access to Truax No-till Seed Drills. Considering the relatively exorbitant price of such equipment, resistance may exist on the state level for buying such drills. One of the responsibilities of the previously discussed consultants or Roadside Native Vegetation Managers might be to arrange rental relationships between Truax drill owners and state DOTs.

2. Software to Track Statewide NWSG Colonies and Their Expansion

As each state locates and augments existing colonies of NWSG and establishes new populations, maintenance departments will need to keep track of these colonies to insure they receive different mowing regimens from those conducted on cool-season grass populations. Not

only do NWSG populations get mowed less often, they get mowed at a taller height. It will be important to either find or develop a software program with which maintenance programs can track their mowing regimens.

3. Increasing the supply of locally harvested and grown ecotypical native seed for the New England region

A long term goal for stakeholders concerned with increasing New England native plant communities and pollinator populations involves creating a strategy to increase the supply of ecotypical grass and forb seed native to the New England region. Currently, few native seed growers exist in the New England region and their supply would not meet the eventual needs of all six New England DOTs. Most large scale native seed growers currently exist in regions far removed from New England. Few grow ecotypes harvested from the New England region. As a result, the current supply of available seed derives from plants that have evolved to climatic conditions unlike those of New England. Introducing on such a large scale seed supplies with genetics different from New England stands risks genetically compromising existing native populations. One of the objectives of changing DOT roadside revegetation protocols involves restoring regional ecological functions. Introducing ecotypes from outside New England risks weakening the current gene pool of existing plant populations or introducing aggressive strains that would act in an invasive manner and throw off the region's ecological balance. Therefore, the rate at which New England DOTs implement these new roadside vegetation protocols will depend on the ability of the region to meet the emerging demand that created by these new practices.

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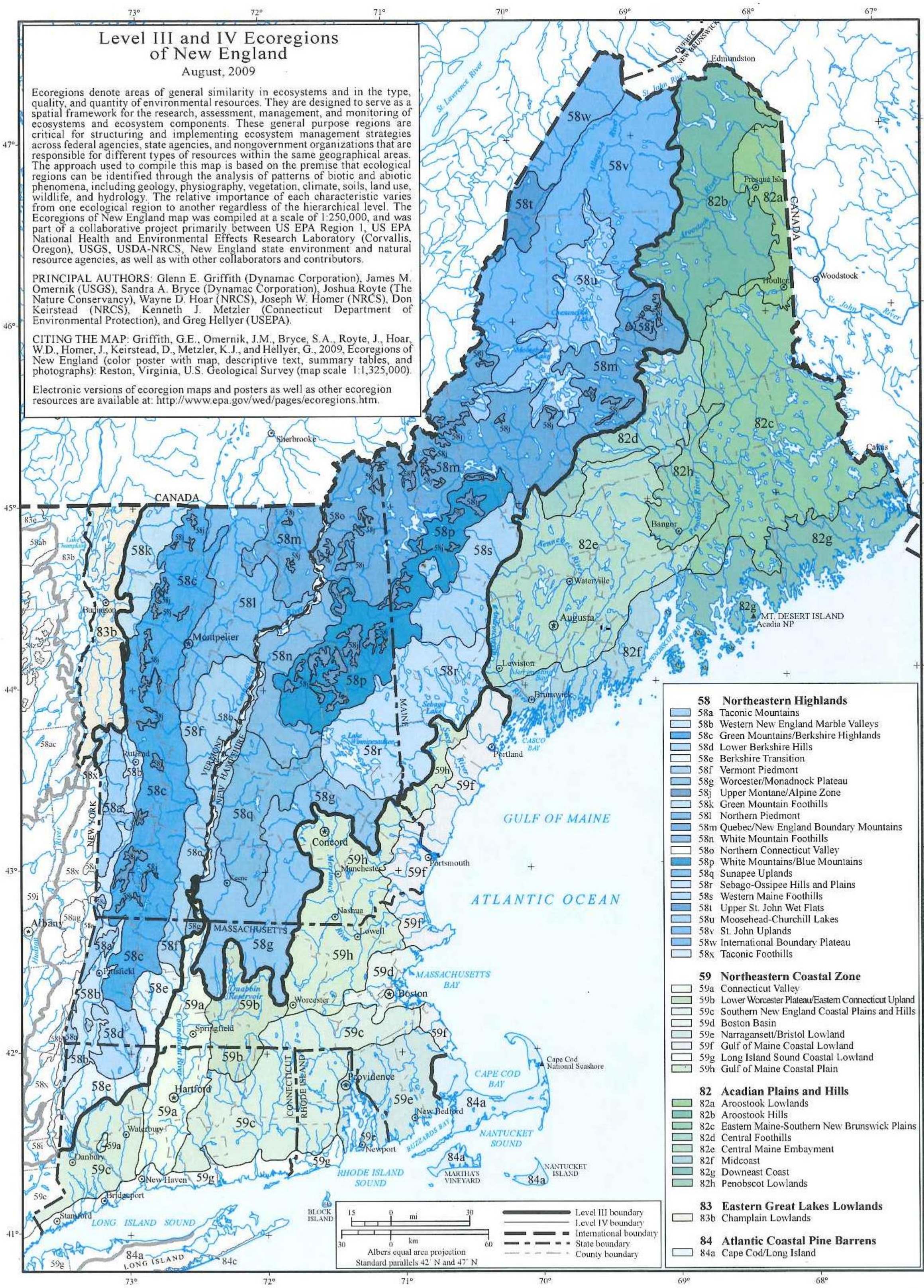
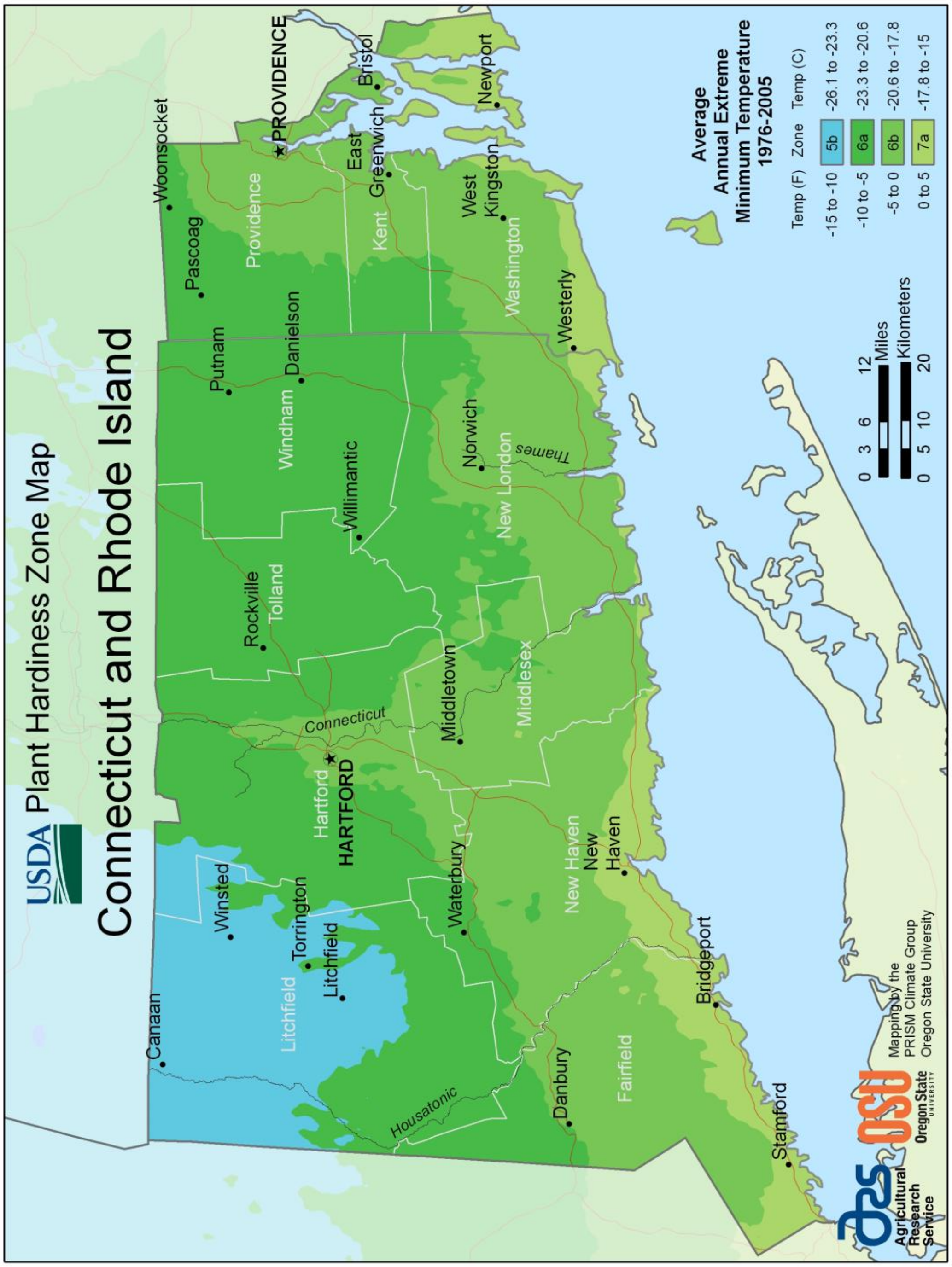
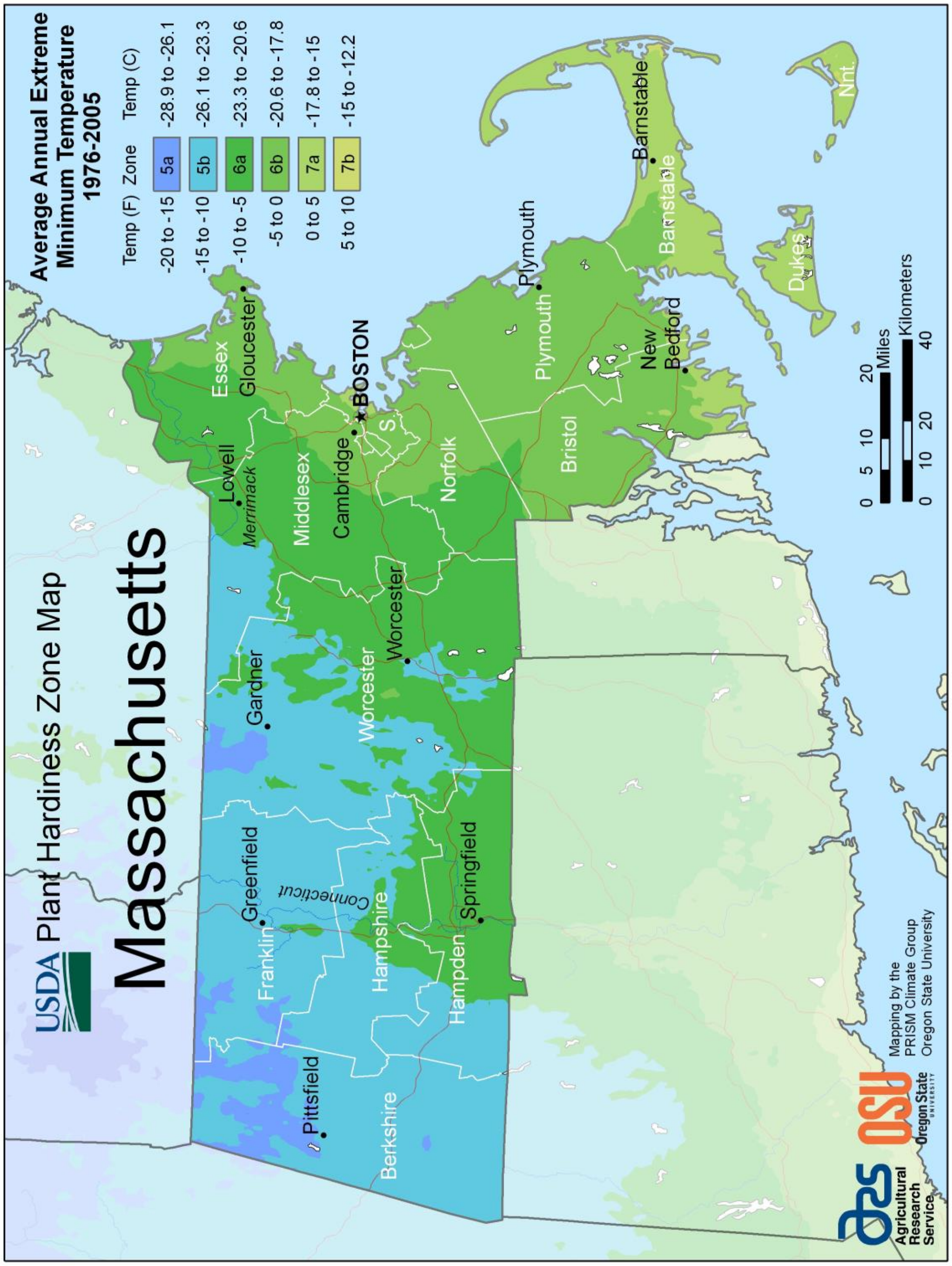
Appendix A – New England E.P.A Ecoregion Map

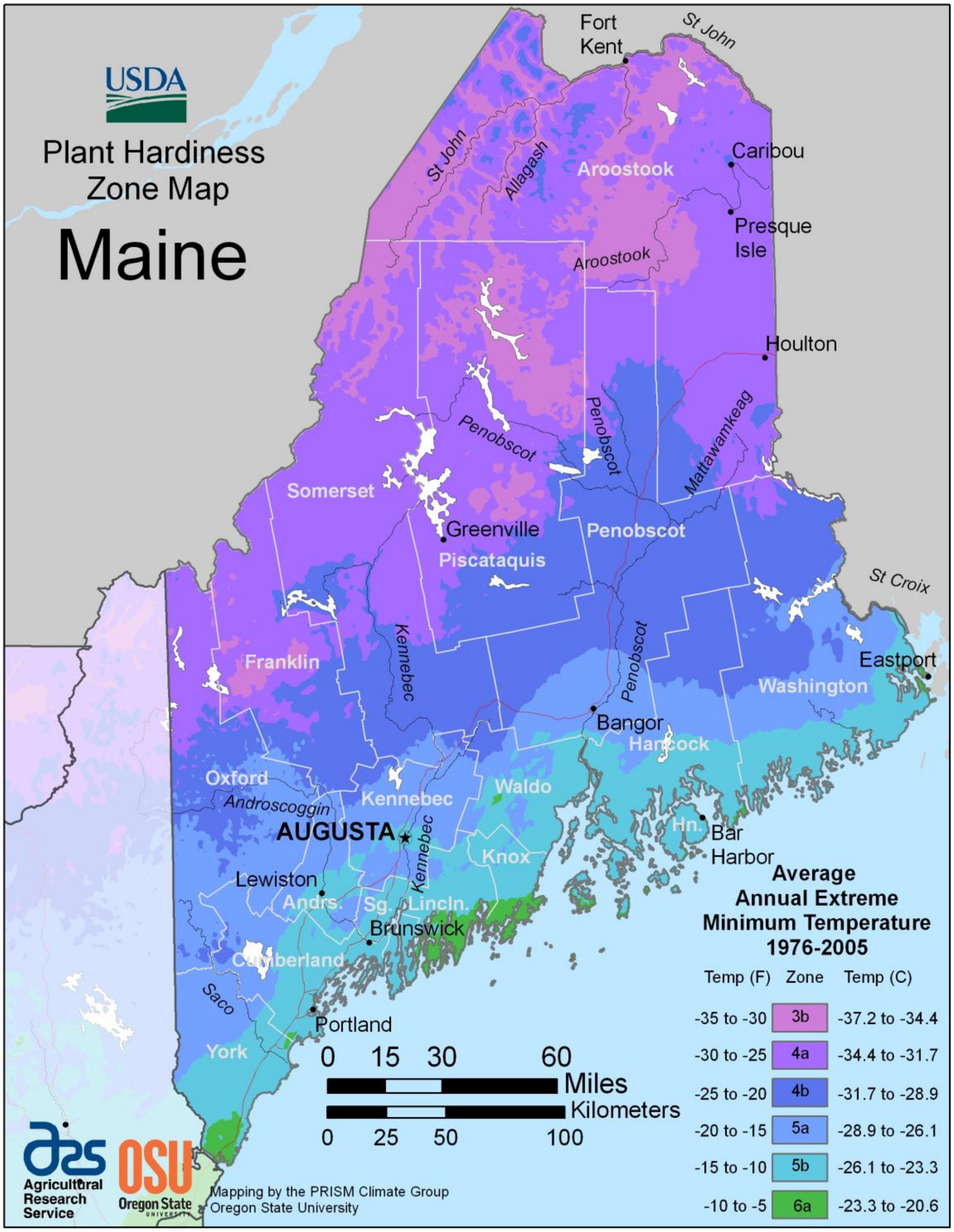


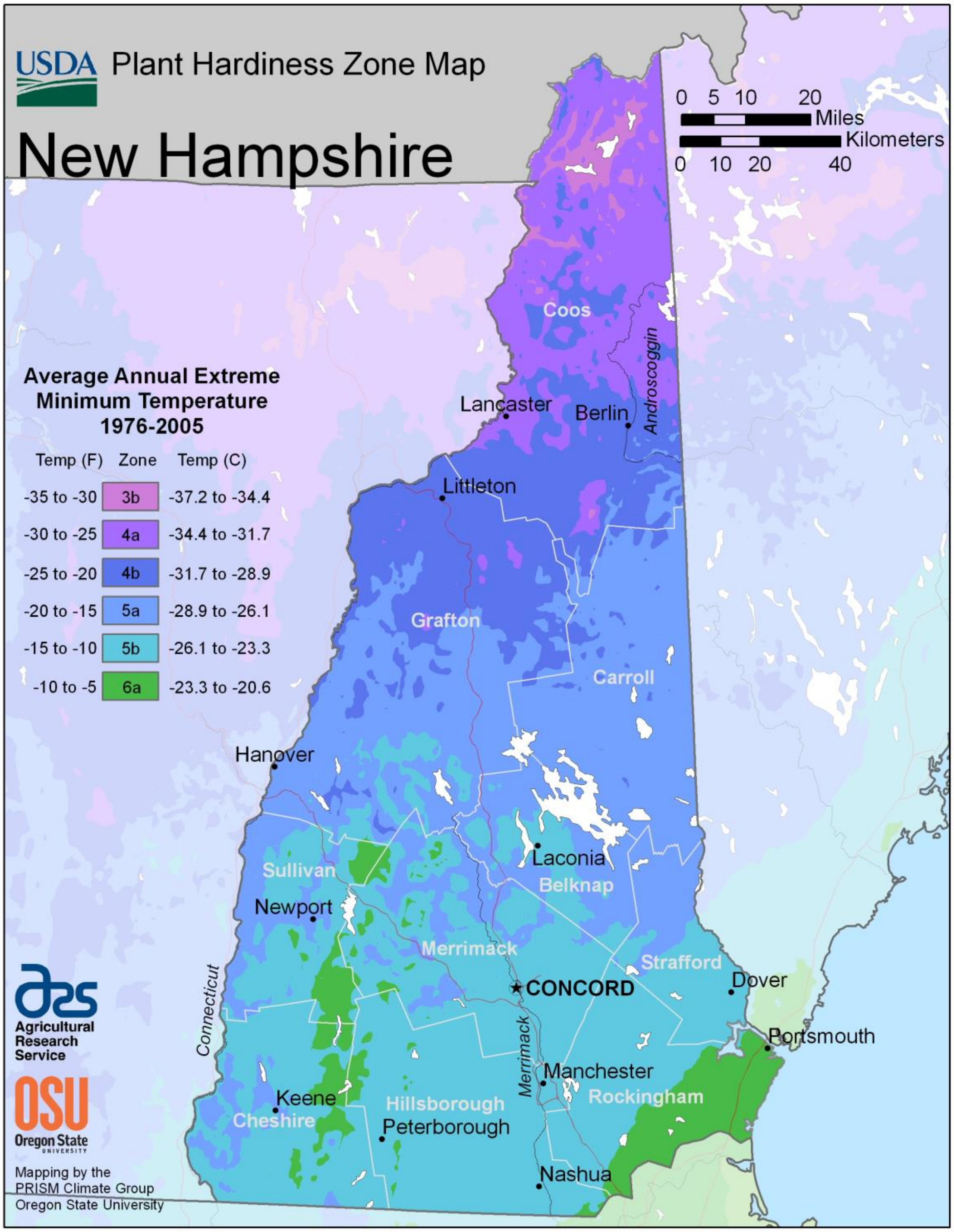
Appendix B – New England State U.S.D.A. Hardiness Zones



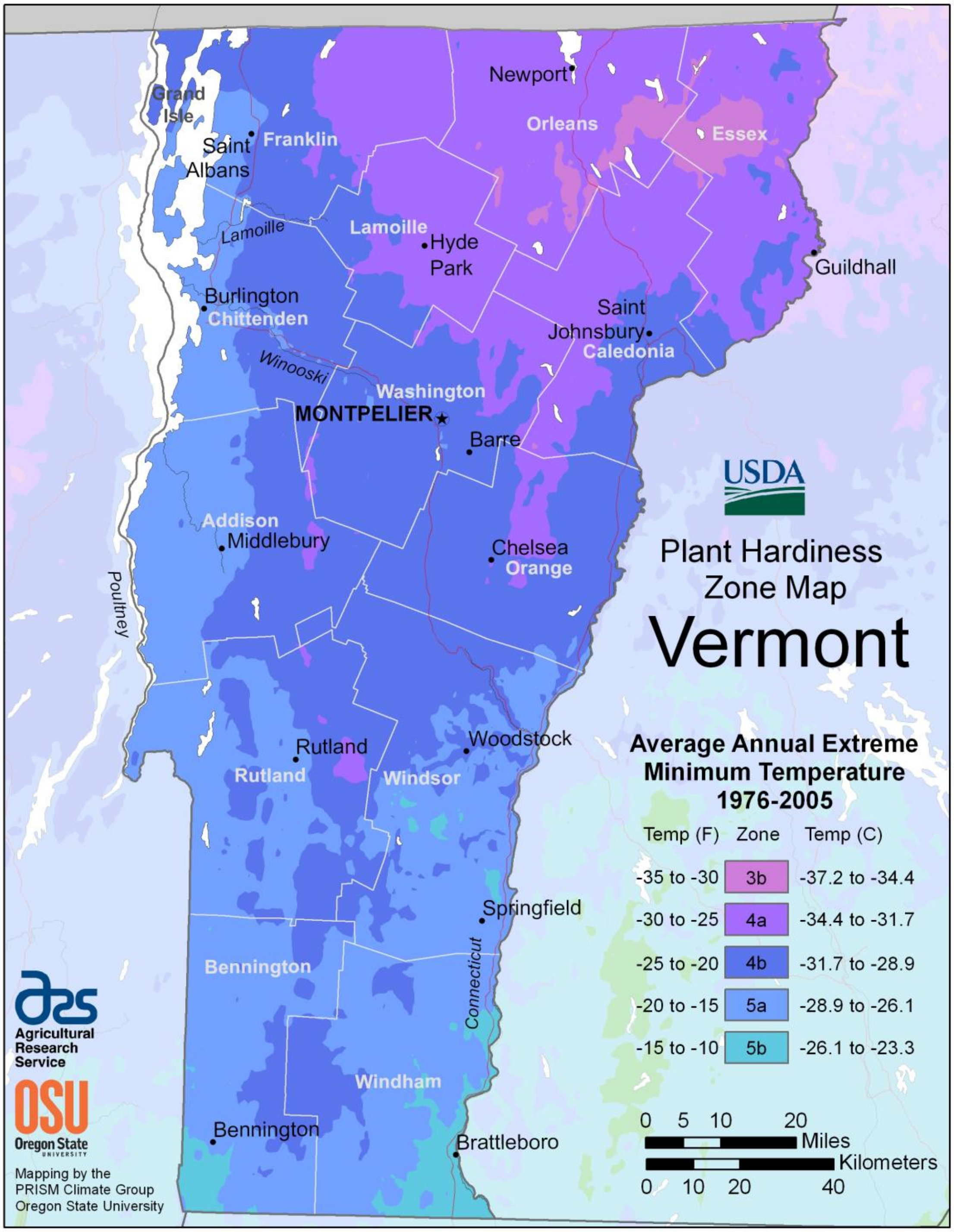


USDA Plant Hardiness Zone Map
Massachusetts
Average Annual Extreme Minimum Temperature 1976-2005
Temp (F) Zone Temp (C)
-20 to -15 5a -28.9 to -26.1
-15 to -10 5b -26.1 to -23.3
-10 to -5 6a -23.3 to -20.6
-5 to 0 6b -20.6 to -17.8
0 to 5 7a -17.8 to -15
5 to 10 7b -15 to -12.2
Pittsfield
Berkshire
Franklin
Greenfield
Connecticut
Hampshire
Hampden
Springfield
Gardner
Worcester
Worcester
Lowell
Merrimack
Middlesex
Cambridge
Norfolk
Essex
Gloucester
BOSTON
Bristol
Plymouth
Plymouth
New Bedford
Barnstable
Barnstable
Dukes
Nnt.
0 5 10 20 Miles
0 10 20 40 Kilometers
Mapping by the PRISM Climate Group Oregon State University
Agricultural Research Service
OSU Oregon State University


USDA
Plant Hardiness Zone Map
Maine
Fort Kent
St John
Caribou
Aroostook
Allagash
Presque Isle
Houlton
Penobscot
Mattawamkeag
Somerset
Greenville
Piscataquis
St Croix
Franklin
Kennebec
Eastport
Washington
Bangor
Hancock
Oxford
Androscoggin
Waldo
AUGUSTA
Knox
Hn.
Bar Harbor
Lewiston
Andrs.
Sg.
Lincln.
Brunswick
Cumberland
Saco
Portland
York
Average Annual Extreme Minimum Temperature 1976-2005
Temp (F) Zone Temp (C)
-35 to -30 3b -37.2 to -34.4
-30 to -25 4a -34.4 to -31.7
-25 to -20 4b -31.7 to -28.9
-20 to -15 5a -28.9 to -26.1
-15 to -10 5b -26.1 to -23.3
-10 to -5 6a -23.3 to -20.6
0 15 30 60 Miles
0 25 50 100 Kilometers
Agricultural Research Service
OSU Oregon State University
Mapping by the PRISM Climate Group
Oregon State University



USDA Plant Hardiness Zone Map
New Hampshire
0 5 10 20 Miles
0 10 20 40 Kilometers
Average Annual Extreme Minimum Temperature 1976-2005
Temp (F) Zone Temp (C)
-35 to -30 3b -37.2 to -34.4
-30 to -25 4a -34.4 to -31.7
-25 to -20 4b -31.7 to -28.9
-20 to -15 5a -28.9 to -26.1
-15 to -10 5b -26.1 to -23.3
-10 to -5 6a -23.3 to -20.6
Coos
Lancaster
Berlin
Androscoggin
Littleton
Grafton
Carroll
Hanover
Laconia
Belknap
Sullivan
Newport
Merrimack
Strafford
CONCORD
Dover
Connecticut
Portsmouth
Merrimack
Manchester
Keene
Hillsborough
Rockingham
Cheshire
Peterborough
Nashua
Agricultural Research Service
OSU
Oregon State University
Mapping by the PRISM Climate Group Oregon State University


USDA
Plant Hardiness Zone Map
Vermont
Average Annual Extreme Minimum Temperature 1976-2005
Temp (F) Zone Temp (C)
-35 to -30 3b -37.2 to -34.4
-30 to -25 4a -34.4 to -31.7
-25 to -20 4b -31.7 to -28.9
-20 to -15 5a -28.9 to -26.1
-15 to -10 5b -26.1 to -23.3
0 5 10 20 Miles
0 10 20 40 Kilometers
Grand Isle
Saint Albans
Franklin
Newport
Orleans
Essex
Lamoille
Hyde Park
Guildhall
Burlington
Chittenden
Saint Johnsbury
Caledonia
Winooski
Washington
MONTPELIER
Barre
Addison
Middlebury
Chelsea
Orange
Poultney
Rutland
Woodstock
Windsor
Springfield
Bennington
Connecticut
Windham
Brattleboro
Agricultural Research Service
OSU
Oregon State University
Mapping by the PRISM Climate Group Oregon State University

Appendix C– Obtaining GPS Coordinates

Using iPhone Compass app to Obtain GPS Coordinates

iPhone's have built in GPS to display the latitude and longitude coordinates of your current location. Follow these steps to find your location coordinates in degrees, minutes and seconds:

1. Make sure that Location Services is ON. Navigate to Settings -> Location Services -> ON

2. In the list of apps under Location Services, make sure Compass is ON

3. Press the Home button to exit Settings

4. Open the Compass app

Your current GPS coordinates are displayed at the bottom of the screen.

Using Google Maps on a Computer to Obtain GPS Coordinates

Unfortunately, Google Maps do not easily provide coordinates on a cellphone. However, it is very easy using a computer to get the coordinates of a site by finding the site on a Google map:

1. Open Google Maps.

2. Find the site on the map.

3. Right-click the place or area on the map.

4. Select **What's here?**

5. A card appears at the bottom of the screen with the latitude and longitude coordinates. If the roadside is on a road with numbered street addresses, the nearest street, town, state, and zip code will also appear.

Appendix D – Web Soil Survey Instructions Brochure

Soil Survey Data

Soil survey data are a product of the National Cooperative Soil Survey, a joint effort of the USDA Natural Resources Conservation Service and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants.

Web Soil Survey (WSS)

The Web Soil Survey provides agricultural producers, agencies, Technical Service Providers, and others electronic access to relevant soil and related information needed to make land-use and management decisions. The WSS:

- Provides an alternative to traditional hardcopy publication,
- Provides the means for quicker delivery of information,
- Provides electronic access to full soil survey report content,
- Provides access to the most current data,
- Allows customers to get just the information they want, and
- Provides customers with the ability to download spatial and tabular soils data for use in GIS (replaces functionality of former Soil Data Mart).

Current, Custom
Soil Maps & Reports:
Fast.
Free.
Friendly.

Print a Hydric Soil Map

- Complete Steps 1, 2, and 3
- From the "Soil Data Explorer" tab, click on the "Suitabilities and Limitations for Use" tab
- Click on "Land Classifications"
- Click on "Hydric Rating by Map Unit"
- Click the "View Rating" button
- Click the "Legend" tab to open or close the map symbol legend
- Click the "Printable Version" button
- Click the "View" button
- On the browser menu bar, select File and Print; or click the print icon

Print a Soil Chemical Properties Report

- Complete Steps 1, 2, and 3
- From the "Soil Data Explorer" tab, click the "Soil Reports" tab
- Click on "Soil Chemical Properties"
- Click on "Chemical Soil Properties"
- Click the "View Soil Report" button
- Click the "Printable Version" button
- Click the "View" button
- On the browser menu bar, select File and Print; or click the print icon

USDA NRCS

National Cooperative Soil Survey

USDA is an equal opportunity provider and employer.

July 2013

USDA NRCS Natural Resources Conservation Service

Web Soil Survey

http://websoilsurvey.nrcs.usda.gov

Define.
Search / Locate

Collect.
Analyze Data

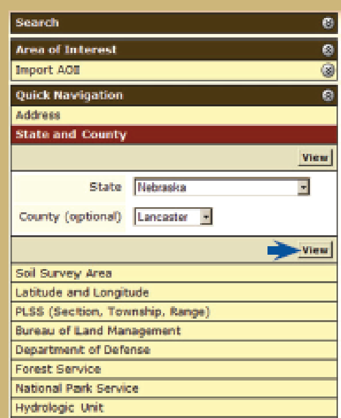
Develop.
Custom Reports & Maps

"Helping People Help the Land"

Accessing Web Soil Survey

- Open the Web Soil Survey (WSS) site at: http://websoilsurvey.nrcs.usda.gov and click the "Start WSS" button.

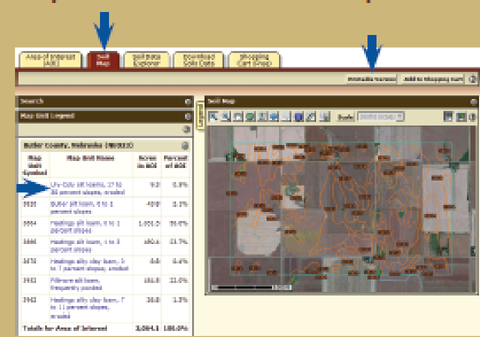
Step 1. Define Your Area of Interest (AOI)



- Several methods are available to zoom into a geographic area of interest. You can enter an address; select a state and county; enter section, township, and range information; or you can import a boundary file from your local computer to set the AOI.
- Click the "View" button to see the area.

- Use the zoom in tool (plus sign) to click and drag a rectangular box around a specific area. Repeat, as necessary, to zoom further.
- Select an AOI tool to draw a rectangular box or irregular polygon that defines the AOI and allows selection of associated soil data. Once the AOI has been defined, you can save it for use at a later date.

Step 2. View and Print Your Soil Map



- Click on the "Soil Map" tab.
- Click on a map unit name to view a map unit description. Click the X to close the narrative.
- Print your soil map by clicking on the "Printable Version" button; then click the "View" button. On the browser menu bar, select File and Print; or click the print icon. Close the window.

Step 3. Explore Your Soil Information

WSS generates thematic maps of soil interpretations and chemical or physical properties. Tabular data reports are also available.

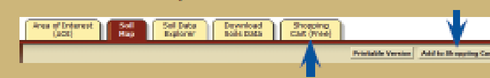
- Click on the "Soil Data Explorer" tab.

- Click on the tabs below "Soil Data Explorer" and explore available information (default tab is "Suitabilities and Limitations for Use").

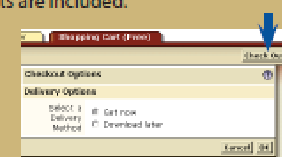
Step 4. Add Items to the Free Shopping Cart and Check Out

WSS allows you to collect a variety of thematic maps and reports in the Shopping Cart, then print or download the content into one file or document.

- Soil map, map unit legend, and map unit descriptions are automatically added.

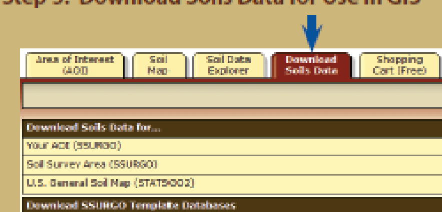


- Items viewed in Step 3 can be added by clicking the "Add to Shopping Cart" button.
- View your cart contents by clicking the "Shopping Cart (Free)" tab. Items checked on the Table of Contents are included.



- Get your Custom Soil Resource report.
  - Click the "Check Out" button
  - Select a delivery option and click OK

Step 5. Download Soils Data for Use in GIS



WSS now allows you to download spatial and tabular SSURGO and STATSGO2 soils data for use in your local GIS. SSURGO data can be downloaded for your defined AOI or for a soil survey area. STATSGO2 data can be downloaded for individual states or for the whole U.S.

NOTE: At any time during Steps 2, 3, 4, or 5, you can redefine the soil map location by clicking on the "Area of Interest" tab and clicking the "Clear AOI" button. Repeat Step 1.

Appendix E – Sidebar: Site Preparation

Mark Brownlee, a Principal with ArcheWild, an ecological restoration and sustainable landscape services firm, has extensive experience establishing native plant communities as part of ecological restoration projects for both government and private clients. Mark believes that site preparation should not be rushed - "Prep can be expedited but with significant risk" – and sees a year or more of site preparation as time well spent. When his firm was establishing a 31 acre research meadow in New Jersey, they used the following site prep time table:

Year 1: Spray-Spray again-Till-Cover crop-Mow

Year 2: Spray-Spray again-Cover crop-Mow

Year 3: Plant

While the specifics of which herbicides and cover crops were used are important, the more important point is that Mark believes that two years of site preparation plays a valuable role in successful site establishment. Those two years of prep help to prevent later challenges resulting from weed pressure.

Waiting two years before planting seed may seem excessive for a government agency like a Department of Transportation, especially compared to the short-time frame it take introduced cool season grasses to establish. However, if this extra time guarantees more successful native plant community establishment, thus preventing the waste of time, effort, and money resulting from establishment failure, then that is time well spent.

Appendix F – Sidebar: Sawdust as Planting Medium for Seed

We tested the establishment technique promoted by Susan Barton from the University of Delaware that uses sawdust as a medium for planting native seed and our initial trials have shown promising results.

For our first test plot, a local lumber mill delivered a dump truck full of sawdust to one of our demonstration plots along Route 6 in Connecticut. The dump truck drove onto the exit roundabout planting site and distributed the sawdust onto the field we had prepared with an application of glyphosate. The driver tilted the truck bed and slowly moved forward, allowing the sawdust to spill upon the designated area. Our team followed close behind, spreading the sawdust evenly using rakes. We then incorporated the seed mix into the sawdust using rakes.

We probably used more than the optimal amount of sawdust. The ideal depth is ½" to 1". Our plots measured between 2.5" to 3". Although we saw significant initial seed germination, we later observed seedling decline, especially for legumes and forbs. We attributed the seedling demise to an especially dry summer season and the inability of the seedling roots to penetrate the sawdust and establish in the soil.

While we observed less weed pressure at the planting site compared with our hydroseeding and broadcast demonstration plots, a population of crabgrass did blanket the site. However, the decrease in crabgrass density appears to have resulted in a greater rate of seedling survival, especially for little bluestem and purpletop grasses. Meanwhile, we noticed that the grasses

planted using sawdust were more mature and rigorous than those established at other sites. Most plants displayed increased numbers of blades and taller heights.

Although we now know that the sawdust worked as an effective planting medium, we initially thought otherwise. After we observed late season seedling demise at the end of the first growing season and saw little more than a mat of dead crabgrass at the beginning of the second growing season, we believed our trial had failed. We tried to salvage half of the site by removing the layer of dried crabgrass blanketing it. Only later in the second season did we realize that our removal of the crabgrass thatch would unexpectedly impact the survival rate of the seed mix species. On the half where we removed the dead crabgrass, little bluestem constituted the majority of the plant community. On the half where the dried crabgrass remained, purpletop dominated the plant population. We attribute the difference in species survival rates to the moisture requirements for each grass species. Little bluestem thrives in drier sites while purpletop thrives in slightly more moist sites. The crabgrass appears to have acted as a moisture retaining mulch cover that favored purpletop survival to that of little bluestem.

Appendix G – Side Bar: Coated Fluffy Seeds

The bearded seed awns of some native warm-season grasses, such as little bluestem and broomsedge, provide these species an apparatus by which they can disperse in nature via wind. However, while these light, feathery structures play an important role in the natural spread and survival of these grasses, they also complicate human attempts to establish these species. One of the most critical factors in successful native seed establishment is seed-to-soil contact. Not only does the down of the awn provide a cushion that suspends the seeds above the soil surface, but these fluffy structures interfere with the ability of these native grass species to flow effectively out of common grain drills and turf grass seed spreaders, which were developed to plant clean, hard, relatively heavy, free-flowing seeds, such as wheat, soybeans, alfalfa, and cowpeas or fescues and ryegrasses.

Many native seed growers try to remove as much of the awns along with other chaff during the seed cleaning process. However, removal of all awns material is difficult and prohibitively expensive.

Colonial Seed Company of Windsor, Connecticut has developed a proprietary seed enhancement called Colony CoatTM that helps address some of the challenges created by fluffy awns for native warm-season grasses. Colony CoatTM encases the seed in a moisture-holding gel polymer, which doubles the weight of the seed and increases the seed delivery ballistics, which helps to improve seed-to-soil contact. In addition, the coating inoculates the seed endo mycorrhizae, which helps young plants capture nutrients essential for establishment.

Appendix H – Seeding Calendar

Seeding Calendar

While May and June are ideal seeding months for warm-season grasses in most of New England, road construction projects rarely are completed before this optimal seeding window. The following seeding calendar provides suggestions for protecting slopes and improving seeding success throughout the year.

January to mid-March

Occasionally, winter months provide windows of opportunity for frost seeding, away of incorporating native seed into the soil if no-till seeds drills are unavailable. This practice of spreading seed over bare soil   can take place if the soil becomes friable – loose or porous – following cycles of freezing and thawing.

Timing is essential for successful frost seeding:

- It requires a readiness of materials and a willingness to jump at the opportunity when the proper time avails itself.
- Inclusion of *Avena sativa* (grain oats) as a cool-season nurse crop.
- Avoid frost seeding areas covered with ice or snow. Occasionally native seed can be sown on top of snow. This is not technically frost seeding, but serves as an effective seeding method on relatively leveled sites.
- It is not recommended frost seeding on slopes.

Late March through April

As long as proper site conditions exist - unfrozen soil and free of muddy ground resulting from thawing snow ground - this time could possibly allow for successful seeding. The site would have required proper preparation in terms of herbicide application in the fall to eliminate cool-season grass and weed competition. Oats would need to be included in the seed mix as cool-season nurse crop. Warm season grasses will not germinate until soil temperatures reach 60° F.

May and June

As previously mentioned, these months provide optimal conditions with the best soil temperature and moisture conditions for germination and survival of warm-season species, including most tall warm-season grasses and forbs/wildflowers.

July and August

Although successful plantings could theoretically occur during these months, hot, dry summer conditions are generally less conducive for planting natives and will require more inputs, especially in the form of added irrigation. Consider using a placeholder temporary seeding in the form of a cover crop at this time, which could help prevent weed and invasive species encroachment until permanent, native seeding can take place in the fall or the following spring.

If work schedules require native seeding during these months:

- Drill, rather than hydroseed, for maximum seed to soil contact. Hydroseeding needs moisture to breakdown and the seeds could dry out while sealed beneath the hyroseed mulching.
- Increase seeding rate 25%, since germination will be decreased from seed desiccation.

- Include appropriate nurse crop: *Avena sativa* (grain oats) can be used until August 1st;
  Secale cereale (grain rye) thereafter.
- To maintain consistent moisture, mulch with straw - crimping or tacking straw into place.
- Insure that outside irrigation can be brought to the site

September and October

Native seed planted this late in the season will unlikely develop extensive root systems to overwinter. Nevertheless, some of these plantings do succeed, perhaps because a large proportion of the seed will not germinate until spring. Only experimentation within each ecoregion will reveal whether this is a viable time for seeding.

- Stabilize erodible sites with inclusion of *Secale cereale* (grain rye) as a cover crop
- Increase seeding rates by 25%.

November and December

Dormant seeding can prove a viable option on level ground but may prove less viable on erodible slopes. Cover crops seeded this late won't provide erosion control until spring. The majority of native seed will remain dormant over winter. While some forb species that require stratification do better when dormant seeded, some native grass seed planted at this time will deteriorate over winter.

- Erodible sites should be stabilized with hydromulch or crimped/tacked straw.
- Increase warm-season grass rate 25%.

Appendix I – Recommended Nurse Crops/Companion Crops

(Adapted from: Brandt, J, K. Henderson, and J. Uthe. (2015) *Integrated Roadside Vegetation Management Technical Manual: Iowa's Roadside Resource*. Ed. Maria Urice.: USDA-Natural Resources Conservation Service / Iowa DOT's Living Roadway Trust Fund.)

Recommended Nurse Crops/Companion Crops:

(Planted with the native seed) – Per acre

Spring

- 1.5 bushels oats - or
- 1 bushel oats and 5 lb. annual rye

Summer

- 2 bushels oats - or
- 1 bushel oats and 10 lb. annual rye

Fall

- 30 lb. winter wheat

Recommended Temporary Seedings/Stabilizer Crops (for native seeding the following spring) – per acre

Summer

- 1 bushel oats plus 10 lb. annual rye and one of the following warm-season species:

5 lb. piper sudan grass

10 lb. millet (Japanese or Pearl varieties)

30 lb. sorghum (grain or forage)

Fall

• 20 lb. annual rye - or

• 60 lb. winter wheat

Caution: For native plantings, many practitioners recommend winter wheat (*Triticum aestivum*) over winter rye (*Secale cereale*). Winter rye* is taller, more persistent and possibly allelopathic, chemically inhibiting the growth of wildflowers. Do not seed piper sudan grass, millet or sorghum too heavily. A single heavy rain can cause mass germination.

*It is important to distinguish among the various species of rye:

- Annual rye (*Lolium multiflorum*)
- Perennial rye (*Lolium perenne*)
- Winter, cereal, or grain rye (*Secale cereale)*

Appendix J - Profiles of Cover Crops

(Adapted from: Salon, P.R. and C.F. Miller. 2012. *A Guide to: Conservation Plantings on Critical Areas for the Northeast.* USDA, NRCS, Big Flats Plant Materials Center, Corning, NY)

Cereal rye (*Secale cereale*) – also called winter rye or grain rye - can be planted later in the season than all other temporary covers. The crop prefers well-drained soils but tolerates poorly drained soils, and can even grow in heavy clay or sandy soils. It also tolerates a wider range of pH – from 4.5 to 8.0 - and lower soil fertility soils than do other winter grains. Cereal rye's well-developed fibrous root system reduces leaching of soil nitrates. Its top growth provides soil cover and suppresses weeds. However, its productive spring growth can be difficult to manage. Some research indicates cereal rye exhibits allelopathy, wherein its plant tissues and root exude compounds that inhibit germination and growth of weed seeds. However, these same compounds can impact small seeded crops if planted immediately following incorporation of cereal rye residue into soil.

Oats (*Avena sativa*), a spring grain crop, produce abundant biomass when planted from early August to the beginning of September. Since oats will winter kill, they provide less of a spring management problem than will cereal rye. However, they also will not recycle nitrogen. Because their residue degrades quickly in the spring, oats offer limited soil erosion protection. They work well as a nurse crop for cool season species and, at reduced rates, for warm season grasses and forbs. Oats prefer well-drained, fine sandy loam to clay soils, and tolerate pH of 5 to 8.5.

Wheat (*Triticum aestivum*), an annual, is planted in the fall to germinate and develop into young plants that remain in the vegetative phase during the winter and resumes growth in early spring. Since wheat requires slightly higher soil temperatures to germinate and grow, it should be seeded

at least a week earlier than cereal rye. While wheat prefers well-drained silt loam or clay loam soils, it will grow in fine sandy loam to clay soils and tolerates a pH of 5 to 8.5. Because wheat produces less biomass in the spring than cereal rye, less biomass remains for killing or interfering with seeding in the spring. Susceptible to Hessian flies, wheat should not be grown in the fall prior to the Hessian fly free date to avoid spreading this insect pest. If a roadside site borders wheat production fields, consider using crops Hessian flies will not damage, such as rye, barley or triticale (× *Triticosecale*), a hybrid of wheat (*Triticum*) and rye (*Secale*).

Barley (*Hordeum vulgare*), a spring or winter annual, is not typically grown as a winter cover north of Plant Hardiness Zone 7 because young seedlings undergo winterkill at temperatures around 15° F. Therefore, use spring cultivars and plant in the spring unless you plant early and can tolerate some winterkill. It prefers well-drained loamy soils and tolerates drought better than the other cereal grains. While it better tolerates salinity and alkalinity than other cereal ryes, it is less tolerant of acidic soils, requiring a pH of 6 to 8.5. Although it hosts the barley yellow dwarf virus, which can also infect wheat, it is not susceptible to Hessian fly, another wheat pest.

Foxtail or German millet (*Setaria italic*), a warm season annual grass, can be used as a smother crop that produces less biomass than sorghum-sudangrass. Foxtail millet grows between 2 to 5 feet, and should be cut before seed matures to avoid becoming a weed problem. It grows well on well-drained loamy soils with a pH of 5.5 to 7.5. It does not tolerate waterlogged or extreme droughty coarse sandy soils. Plant in a firm, well-prepared seedbed after soils have warmed and tillage can control the first flush of weeds. A carrier of both the wheat spindle streak mosaic virus and the wheat curl mite that transmits the disease, foxtail millet can serve as an over-summering host, despite not being bother by these pests.

Teff (*Eragrostis tef*), a warm-season grass, can suppress weeds when successfully established at high densities. Teff, which has very fine seed with 1.3 million seeds per pound, requires a low seeding rate of 5 to 8 pounds per acre. To assure good germination, prepared a firm seed bed and seed at very shallow depth. Plant once soils have warmed and tillage can control the first flush of weeds Teff tolerates dry conditions better than buckwheat or sudangrass, and requires less maintenance since buckwheat requires more when it matures and sudangrass requires mowing. Teff needs minimal mowing and, since it generally does not produce seed, volunteers do not become an issue

Sorghum-sudangrass (*Sorghum bicolor* X *S. sudanense*), a cross between forage or grain sorghum and sudangrass, is a warm season annual grass that grows well in hot, dry condition. Able to reach 6 to 10 feet, sorghum-sudangrass produces large quantities of biomass useful for soil organic matter enhancement. Apply at least 50 pounds per acre to improve biomass production on nitrogen deficient sites. While it grows in well-drained to somewhat poorly drained soil, but it has low flood tolerance. It achieves optimum production between pH 6.0 and 6.5 but tolerates pH 5.0 to 8.0. Sorghum-sudangrass, which displays allelopathic properties, suppresses weeds very effectively. Its roots help control erosion, forage exceptionally well for soil nutrients, especially nitrogen, and reportedly are highly effective in remediating compacted soils caused by construction equipment. Mowing is recommended when it reaches 3 feet. Allowed to grow taller, it can produce a large amount of residue, becoming a management problem for subsequent seed bed preparation. Sudangrass, which has more narrow stems, is easier to manage and suppresses weeds better.

Buckwheat (*Fagopyrum esculentum*), a very rapidly growing, broadleaf summer annual with many lateral branches and fibrous superficial roots, can grows to 2.5 feet in height. With a pH

range of4.5 to 7.5, buckwheat tolerates acidic and infertile soil better than any other grain crop. Best suited to light to medium textured, well-drained soils, such as sandy loams, loams and silt loams, it tolerate poorly drained soils but not flooding. Buckwheat does not break up hardpan and does not grow well on compacted soils. In Plant Hardiness Zone 5, it can be sown from late May to early August. As a smother crop, drill at a rate of 50 pounds per acre, or broadcast at 70 pounds per acre; then shallowly incorporate to 1 inch deep. Within 40 days, it will develop an excellent weed suppressing cover. However, weeds will grow in any gaps wider than 10 inches. Buckwheat flowers in 4 to 6 weeks, providing attractive forage to both insects and pollinators. Buckwheat solubilizes and takes up phosphorus that is otherwise unavailable to other crops, then releases these nutrients to later crops as the residue breaks down. Buckwheat's main disadvantage is that it sets seed quickly and, if not mowed or tilled, goes to seed and becomes a weed problem in subsequent crops.

Appendix K - Types of Mulch

(Adapted from Salon, P.R. and C.F. Miller. 2012. *A Guide to: Conservation Plantings on Critical Areas for the Northeast.* USDA, NRCS, Big Flats Plant Materials Center, Corning, NY)

Mulch plays several important roles in plant community establishment:

1) **Plant growth**
2) **Erosion control**
3) **Moisture retention**
4) **Prevention of seed movement**

Each of the following types of mulch helps achieve these goals to different degrees and do so at varying costs.

Hay vs. Straw vs. Salt Marsh Hay

Hay is an assortment of forage grasses that usually includes seeds of grasses and broadleaf weeds. Therefore, it is better suited for feeding livestock than for mulching.

Straw is a collection of the stems of cereal grains - oats, wheat, barley, rye or triticale – and is popular as a mulch because it rarely contains weed seeds and is readily available.

Salt hay, or salt marsh hay, consists of grasses harvested from salt marshes. Their wiry stems do not mat down or rot as quickly as straw, and any seeds present will not germinate because they require wet, saline soil.

Straw primarily benefits plant growth at a relatively affordable price. Apply straw mulch at the rate of two tons per acre (90 pounds per 1,000 square feet). Spread mulch uniformly by hand or by mechanical methods immediately following seeding, covering approximately 85 percent of

the soil surface. This provides erosion protection and allows adequate light penetration for seedling germination and emergence. For most applications, anchor the straw immediately after placement to avoid movement by wind or water. Straw can be tacked with wood/cellulose fiber spread by hydroseeder at 500 to 750 pounds per acre. For additional protection, add tackifying agents following manufacturer's recommendations.

Hay is an acceptable straw alternative only if weed seed content does not affect the site objectives. Considering the price differential between straw and hay – hay is usually cheaper than straw – hay may appear the more attractive short-term choice. However, weed and forage crop seed can overwhelm the desired vegetation, thus creating costly, long-term challenges. Hay tends to break down faster than straw, requiring heavier application rates. It also requires anchoring on sites subject to wind. Furthermore, hay is more likely to contain mold that can be an allergy problem for workers.

Salt hay, or salt marsh hay is usually the most costly of the three grass/grain-based mulch alternatives. However, it can also be the most effective because the seeds will not germinate without salt water and will instead breakdown and add organic matter to the soil. Apply at the same rate and in the same manner as straw.

Hydraulic Mulch Types

The term **hydraulic mulch** refers to mulches made of one or more of the following types of material: cellulose (paper), shredded wood fiber, blended (wood and cellulose) or bonded fiber matrix. Tackifiers help adhere the mulch to the soil surface and dye provides visual aid during application. The rates at which they are applied range from 2,000 to 4,000 pounds per acre, depending on the material, additives, soil/site conditions and time of planting. Hydraulic mulches

usually last from 3 to 12 months and are used to temporarily protect exposed soil from erosion by wind, raindrop impact and sheet flow while seeding establishes. Additives can extend their longevity. Hydraulic mulching equipment - usually referred to as **hydroseeders** – mix and continuously agitate hydraulic mulches to form and maintain a homogenous slurry. Wood fiber based mulches require mechanical paddle agitated equipment and their slurry should be sprayed under pressure, uniformly over the soil surface at the material application rate based on slope grades as recommended by the manufacturer.

Cellulose fiber mulch is made from recycled newspaper, magazines, or other paper. One of the least expensive fiber mulch, cellulose fiber mulch uses a tackifier to tack straw at 500 to 750 pounds per acre. It has one of the shortest expected longevities – no more than 3 months. It usually comes in bales. However, it also comes in more expensive pelletized forms, which pours easier into hydroseeders or can be broadcast without a hydroseeding machine. When broadcast, the pellets must be watered afterwards to expand the pellets and secure them in place. When used on flat surfaces for turf applications to aid with germination during optimum seeding windows, apply at 1,500 pounds per acre. Do not over apply cellulose mulch; it can create a consistency of papier maché, reducing infiltration and air exchange, thus inhibiting seed germination and establishment. When erosion control is a concern, use a mixture of wood and cellulose fiber mulch.

Wood fiber mulch, manufactured from recycled wood or virgin wood fibers, performs best when applied with tackifiers and has an expected longevity of 3 to12 months. Wood fiber mulches retain water with interlocking fibers and are used to control erosion for slopes up to 3:1.

Blended wood/paper mulches consist of 50 percent to 70 percent wood fiber, 30 percent to 50 percent paper fiber and have an expected longevity of 3 to12 months. It will provide some

erosion control for slopes from 6:1 to 4:1, depending on additives, soil/site conditions, and time of planting. For highly erodible sites, it best to use either wood fiber or bonded fiber matrix type mulches with tackifiers.

Bonded fiber matrix (BFM) consists of a continuous layer/matrix of elongated wood fiber strands held together by water resistant bonding agents, such as soil flocculants, crosslinked hydro-colloidal polymers, or cross-linked tackifiers. Its expected longevity ranges from 3 to 12 months. It forms a lofty, interlocking matrix that creates air and water absorbing cavities, which improve seed germination, reduce the impact of raindrop energy, and minimize soil loss. BFM can be used on slopes up to and including 2:1. To provide effective erosion control, do not apply immediately before, during, or immediately after a rainfall, or when the soil is saturated, since it typically requires 24 hours to dry before rainfall occurs.

Mechanically bonded fiber matrix (MBFM), produced from strands of elongated wood fibers and crimped synthetic fibers and combined with additional binding agents, creates an interlocking mechanism between the fibers. It has one of the longest expected longevities: 12 months or greater. Since MBFM requires no cure time to develop surface protection, it provides immediate protection against erosion and may be used on slopes up to and including 2:1

Soil Stabilization Matting

Erosion control matting and rolled erosion control blankets provide immediate erosion protection. Many are specifically designed to handle higher velocities in concentrated water flow areas, such as swales connected to drainage pipes, and provide more extended periods of erosion control. These typically use straw or coconut fiber mulch between layers of jute (biodegradable), UV degradable or non-degradable netting. Some include a non-degradable fiber layer with 95

percent pore space, which provides more structure for hydraulic seeding over the top. They should be installed up and down the slope and never on the contour. Following manufacturer's recommendations, it is important to staple the mats to achieve a firm, continuous contact between the material and the soil. Typically more expensive than most hydraulic mulching options, these mats vary in cost based on longevity.

Mulch Anchoring

Once mulch is applied it needs to be anchored in place for the time needed to establish a seeding and protect the soil. The following section details the different types of mulch anchoring systems. Refer to Appendix 4f for a summary of mulch anchoring techniques for different mulches.

Mulch Netting

Mulch netting is used as a cover for mulch; it is made from UV degradable plastic, jute, or cotton netting. Coconut fiber has been used as a longer-lasting natural material, bridging the gap between man-made fiber longevity and plant-derived fibers for biodegradability. Individual rolls of netting should be applied up and down the slope never along the contour. Bury the upper end of the netting at the top of the disturbed area in a trench at least 6 to 8 inches deep. Lay out rolls so edges overlap each other by at least 4 inches. When more than one roll is required going down slope, the ends going down the slope should overlap by at least 3 feet. Steel staples are used to fasten these materials to the surface. Installation is difficult on rocky sites. Staple the netting in place using wire staples according to manufacturer's recommendations.