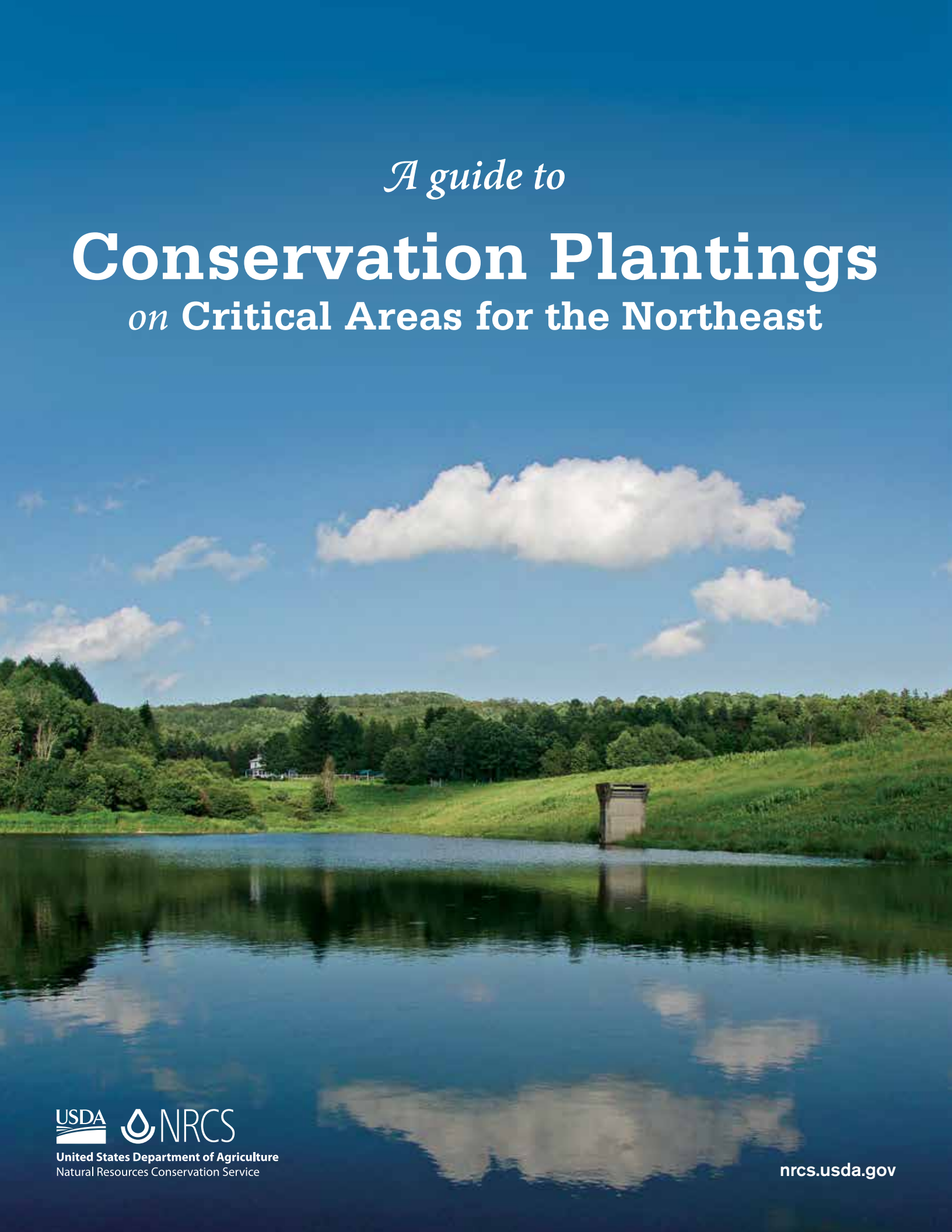
A guide to

Conservation Plantings

on Critical Areas for the Northeast



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A GUIDE TO

Conservation Plantings on Critical Areas for the Northeast

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Table of Contents

Introduction

This guide covers some factors to consider when planning and implementing critical area seedings and conservation plantings in the Northeast U.S., Figure 1b. It discusses the differences between critical area stabilization, conservation plantings, and restoration with an emphasis on critical area stabilization. The use of native species, diversity, and concern for the spread of invasive species is emphasized. It points out the importance of soils, soil organic matter and maintaining soil quality as an integral part of all conservation plantings. It addresses the use of structural erosion and water control measures where needed to facilitate successful seeding and planting. It stresses mulching as an integral part of most critical area seedings and plantings. This guide is divided into sections based on the steps in conducting conservation plantings starting with planning, selecting plant material, purchasing plant materials, and finally to installing the seeding or planting.

The guide presents in Chapter 2, information in both written and tabular format on all recommended plants providing easy access to plant characteristics useful when selecting specific species for planting. The scientific and common names used were obtained from the PLANTS Database, which also provides alternative synonyms. The online version provides direct links to the USDA PLANTS Database where photographs and other information are readily available. PLANTS Database Characteristics have been compiled for over 2,000 species and an additional 500 cultivars from the scientific literature, gray literature, agency documents, and the knowledge of plant specialists. Characteristics data values are best viewed as approximations since they are primarily based on field observations and estimates from the literature, not precise measurements or experiments. If you think the data can be improved, please contact the PLANTS Database.

The guide covers which factors to consider when purchasing seed or plants such as seed certification and pure live seed. It discusses the need to amend soils for pH, fertility, and organic matter. Information is provided on the use of different types of seeding equipment for the different types of seeds and site conditions. Planting methods and maintenance requirements are given for different types of grasses, legumes, forbs, trees, and shrubs based on the propagule type, size and type of planting stock. Chapter 4 covers implementation procedures, while the adjacent appendices contain the plant information in tabular form for convenience. A conservation seed calculator in Appendix 2j and the critical area seed mix table in Appendix 4d will be in a spreadsheet format available on the USDA-NRCS Big Flats Plant Materials Center website.

Refer to your state's USDA Natural Resources Conservation Service's (NRCS) Electronic Field Office Technical Guide (EFOTG) for conservation practice standards and specifications. Additional state and purpose-specific seed mixes and plant recommendations for wildlife habitat improvement, conservation reserve programs, buffers and wetlands, and other conservation practices are available in the EFOTG. The seed mixes and plant recommendations in this guide are not meant to supersede guidelines for government programs that are subject to change. For additional information contact the USDA-NRCS Plant Materials Specialist or Agronomist for your area.

For some conservation plantings the use of herbicides may be necessary. This guide does not recommend specific herbicides, but recommends following the manufacturer's labeling and state pesticide regulations for the state in which the product will be applied. Recommendations for treatment, including specific herbicides, rates, and timing should be obtained from published sources of information. Such sources may be from state land grant colleges, which are based on the current manufacturer's labeling, and are subject to annual reviews. When published recommendations are not available and for additional information relating to herbicide treatment methods, seek advice from the manufacturer and a consultant with the appropriate state pesticide applicator certification.

Many of the references used are currently available on the Internet and are linked in the text in the online version. The current web addresses are given in the reference section for the printed version. The online version of this document is subject to updates of web addresses where possible, addition of new research findings as they become available, and supplemental information pertaining to more species as they become commercially available. This guide is available on the USDA-NRCS National Plant Materials Program and Big Flats Plant Materials Center website.

Chapter 1

Planning Considerations and Site Assessment

Critical Area, Conservation, or Restoration Planting

The purposes for critical area plantings are: stabilization, erosion control, water-quality protection, public safety, and infrastructure protection. Critical sites are often characterized by damage to the soil structure, making the site different from the surrounding ecosystem. Critical area seedings are often used as part of conservation practices like dams, diversion ditches or waterways, where a vegetated cover is required to perform the intended function of the structure or site. In these cases, the vegetative cover should be maintained in grass and legumes by mowing (Figure 1a), thereby preventing natural succession or the growth of invasive species. In some cases, these structures are located within farming systems and selection of species may be for a dual purpose such as for erosion control and forage production. Critical area seedings, in these instances, occur where restoration is not the intended purpose. In other situations, once the site is stabilized and the soil structure has been improved, we would want the site to move toward natural succession, and the selection of pioneer or transition species for planting would accommodate this objective.

Figure 1a. Conservation practices such as diversions and waterways need grasses which are maintained by mowing.

The use of plants to resist soil loss, to slow water velocity, and to protect against shallow slope failure is an integral part of solving critical area problems. Plants are living organisms that may fail due to a myriad of biological and physical stresses, making their successful use more multifaceted than engineered solutions. Plants, through their interaction with the environment, provide benefits to the ecosystem that engineering practices may not. They also solve critical area conservation problems and improve the soil quality of a site at the same time. This is the basis for our discussion of plant materials and techniques for their effective use.

Solving or preventing critical erosion problems is typically achieved by a combination of engineering and plant-based methods. The engineering portion provides the grading, water-control structures, and when necessary, adds mass and physical structure to a site with inert materials such as rock or concrete. The structural portion is usually intended to prevent mass failure of a slope, protect the toe of banks, or redirect stream flows. Engineered earthen structures, such as dams and waterways, are designed and constructed for soil and slope stability and includes vegetative treatments to protect and maintain the integrity of the structure.

A site that is to be disturbed due to construction should have a plan in place that limits the off-site effects of runoff, erosion, and sedimentation. For construction activities meeting certain criteria, the local, state, and federal government mandates a Storm Water Pollution Prevention Plan (SWPPP). For more information refer to the Environmental Protection Agency (EPA) Storm Water Discharges from Construction Activities website. Additional information is provided by state and local municipalities.

Conservation and restoration plantings are used to maintain and enhance natural resources such as soil, water, and air quality as well as wildlife habitat improvement. They are usually conducted on land that has not been severely disturbed by construction activities. When the purpose is restoration, these sites can be planted with the climax species for its ecological community and can proceed toward natural succession. If the site is severely disturbed other practices may be needed such as erosion control, restoring hydrology, improving soil quality and controlling invasive plants prior to the site being planted with the climax species. For some plantings with specific conservation objectives, additional management is needed to maintain the cover established to meet those objectives. For example, if the conservation objective is grassland birds or pollinator habitat improvement, additional periodic mowing or controlled burning management may be necessary to maintain the species and structure of the new planting.

Plants and Risk

When plants are used in critical area treatment, there is a risk of plant loss due to disease, insects, pollutants, or weather extremes. These risks are in addition to failure due to the selection of plant species or ecotypes that are not adaptable to the site. Plants require a period of establishment before they can effectively protect a critical site. During this establishment period, the site is vulnerable to failure. While engineered structures using stone offer near-maximum protection upon completion, using a plant-based solution is a conscious choice accepting greater risk to achieve the long term benefits plants provide to the ecosystem. Plant-based solutions may be less expensive than engineering solutions even when secondary maintenance measures are needed. We advocate the use of native plant materials to solve conservation problems, when they are available and have been proven to be effective. In order to minimize the risk of failure, it is sometimes beneficial to use introduced non-invasive species for critical area stabilization. Introduced species can provide rapid erosion control and stabilization. They can also protect water quality, public safety and prevent severe economic consequences.

Native Plants

For restoration purposes when the site has not been degraded choose plants which represent the climax community for the area that will be planted or if degraded use pioneer species which will lead the site toward natural succession. Use nearby reference ecological communities and consult with the Natural Heritage Program for lists of species typically found within the natural community being planted. Native plants are often used for general conservation plantings such as wildlife habitat improvement, pollinator enhancement, and buffers for water quality. Under these circumstances, native plants are chosen to solve conservation problems or to enhance natural resources, not for restoration purposes, since the species chosen do not represent the climax community. Once a critical area site has been stabilized and soil organic

matter has improved, the introduction of native plants will be more successful and natural succession will proceed. Recognize that it is more challenging to establish native plants by seed, especially non-improved local ecotypes, due to high seed dormancy, poor seedling vigor, and lack of disease and insect resistance. When planting native plants, it is extremely important to follow specific protocols for establishment, for example, pre-treating seeds to cold moist conditions (cold stratification) to break seed dormancy or by fall planting. Cold stratification is the treating of seed by soaking in water (imbibing) then subjecting them to a period of cold temperature just above freezing for 4 to 8 weeks or longer depending on the species. Native plantings may need management practices not easily conducted on steep slopes such as mowing for weed control.

Check whether the plants recommended in catalogs or on websites are native to your state or the plant community in which you are planting or trying to restore. Consult with the Natural Heritage Botany Program in your state, or the Nature Serve Explorer website. If the plant is native, you should also check the status and ranking of the plant to see if the plant species is rare, threatened, or endangered in your state. Federally listed endangered species are not commercially available and cannot be legally planted unless cultivars were developed prior to the Endangered Species Act. It is not advised to plant rare, threatened, or endangered plants.

Due to the cost of seed production and marketing considerations, "local" ecotypes may not be available for your region. Available ecotypes may originate and be produced from outside of the region where they are to be planted. Sometimes native species have been produced for the horticulture trade. It is important to inquire with seed producers and marketers as to the origin of the seed source that they are growing and marketing.

In Chapter 3, we will discuss the native plant certification program of the Association of Seed Certifying Agencies. This program certifies the origin of the seed and how it has been produced to maintain its genetic integrity.

Existing Vegetation

Prior to excavation, a site inventory may reveal existing vegetation that is functional or has aesthetic value. The site may also contain rare, threatened, or endangered species. To save vegetation, leave it in an undisturbed condition in its original location or, if not possible, carefully move it to a better location on-site or remove the vegetation from the site for use elsewhere. Plant moving techniques are site and plant specific and may require permits. Failure, when moving plants, usually involves one or more of the following mistakes:

- The plant is actively growing when moved.
- There is not enough undisturbed root mass and soil moved.
- The new site does not have an appropriate soil drainage class or soil quality.
- Inadequate care is given to the plant after moving.

Successfully protecting plants requires that the boundaries of non-disturbance areas be adequately delineated. Vegetation worth saving should be protected by enforceable contractual agreements. Protecting herbaceous plants in place may be as simple as staying off the area and protecting it from disturbance, sedimentation, erosion, or pollutant run-on. Protecting woody plants in place may be tedious because of the lateral extent of tree and shrub root systems and the long-term effects of root damage. Avoid traffic, grading, soil removal, sedimentation, erosion, or filling in a root protection zone around the tree. The distance needed for protection is determined by measuring the tree trunk diameter at 4.5 feet above the ground in inches and multiplying this value by 2.5 to obtain a value in feet. For example, a 12-inch tree needs a 30-foot diameter root protection zone. Though woody plant root systems may not be directly damaged by limited traffic, the resulting soil compaction can produce long-term problems that may not be evident for 5 to10 years. The functional and aesthetic value of large trees and shrubs can be very high in dollar terms and the ability to replace the damaged plants may simply not exist at any price or in any reasonable period.

Weeds and Invasive Plants

For critical area stabilization, existing vegetation is only a problem when it interferes with obtaining the proper planting bed or when it consists of weeds that will hinder establishment of the desired vegetation. On some sites, the presence of any vegetation is an aid to stability and steps to preserve it should be included in the planting plan. Disturb only as much of a site as is absolutely necessary to reduce environmental impacts and reduce costs of sediment control and revegetation. In some circumstances, the long-term goal for critical area stabilization is for local climax species to naturally colonize the site. However,

invasive plants can interfere with the initial effort and the long-term goal. Effective treatments exist to control weeds. Weeds with low densities or weeds that will fade as the desired vegetation is established may be ignored. Weeds must be controlled when establishing warm season grasses on most agricultural soils in the Northeast as the climate and soils favor cool season grasses and weeds. Warm season grasses are especially useful on droughty sites such as gravel pit revegetation.

Invasive plants are an overwhelming problem that will hinder the establishment of desirable species. Conduct a site assessment to determine their presence and develop a management plan for their control and a plan to prevent the introduction of invasive plants from fill, topsoil, mulch, or other organic amendments. Construction and planting equipment should be thoroughly cleaned after use at a site infested with invasive plants. Due to the ability of invasive plants to rapidly colonize within areas of disturbed soil, it is essential that all disturbed areas be mulched and seeded as soon as possible. If outside the growing season for seed germination, disturbed sites should still be mulched. Sources of mulch should be free of invasive plant parts or weed seeds, therefore the use of straw or wood fiber mulch are preferred over hay. Although some invasive plant species are available commercially, it is of utmost importance that invasive plants not be used on conservation plantings. It is also important to consider invasive insect pests that are in the area to avoid planting susceptible plants. Lists of invasive species are found on state invasive species websites or at the USDA PLANTS Database Invasive and Noxious Weeds web page.

Climate, Weather, and Slope Aspect

The USDA plant hardiness zone (PHZ) map released in 2012 is based on the "average annual minimum temperatures" for each of the zones. These are calculated using the lowest temperatures recorded for each of the years 1976 to 2005, as well as more sophisticated methods for mapping zones between weather stations and considerations for microtopography and lake effect. The PHZ map is helpful when selecting species of plants that are tolerant of expected low winter temperatures. Within plant hardiness zones, climate will vary based on elevation, aspect, position on slope, and location within PHZ. Cultivars and ecotypes within species may differ greatly in winter hardiness, therefore the right cultivar or ecotype may be as important as the right species. Refer to Figure 1b, for a plant hardiness zone map of the Northeast to determine the plant hardiness zone for your location. An online version of this figure is located at the U.S. National Arboretum PHZ website. This guide covers the areas located in zones 3 through 6 although some of the information would pertain to zones 2 and 7. Another resource is the Ecoregion Maps from the (EPA) Western Ecology Division. These maps use geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology to define their boundaries. The relative importance of each characteristic varies from one ecological region to another.

The slope's aspect can affect plant selection, establishment, and management. Slopes with north and northeast aspects can reduce air and soil temperatures and evapotranspiration. This can have a negative impact on warm season grass plantings by slowing their germination, establishment, and performance. In some instances, a northern slope aspect can enhance snow cover thereby reducing the freeze thaw cycle and frost heaving. Conversely, south-facing slopes are generally hotter and drier and can negatively impact seed germination and seedling survival of warm and cool season grasses as well as woody seedlings. Also, position on the slope can influence frost-free periods due to frost pockets when cold air flows down to the bottom of a slope from an adjacent higher elevation. The Great Lakes and other large bodies of water, tend to moderate air temperatures of adjacent inland areas. Low temperatures in winter are not as extreme, and these areas are less prone to late spring and early fall frosts. Smaller bodies of water also have the same effect, usually to a lesser extent. Lake effect snow is a common phenomenon around the Great Lakes and other large lakes increasing total snow fall and snow cover.

Global climate change results in extremes in weather, such as hot, dry periods and intense rainfall events. This can increase the need for conservation plants, and will add to the stress on these plants when used for critical area protection. The winter survival as well as the seed and fruit set of some trees and shrubs can be impacted when planted close to the edge of its plant hardiness zone. Mild falls with late frost can delay hardening off in woody plants leading to winter hardiness concerns. Earlier spring flowering followed by a frost can lead to a reduction or elimination of fruit set. There is an

indication and prediction that the species composition of weeds and the distribution of invasive insects and disease pests may change. Over time PHZ's boundaries are expected to shift due to climate change.

Soil Erosion

Soil erosion is the wearing away of the earth's surface by the forces of water and wind. It is a natural process, which can have striking results, such as the Grand Canyon or the Dakota Badlands. Most often, erosion is a slow, less dramatic process. When the natural landscape is disturbed by activities of humans such as tillage, timber harvesting, urban development, mining, road construction, or overgrazing, erosion can become accelerated and destructive. Healthy, productive soil is lost and sediments damage or clog water bodies, rivers, streams, and reservoirs.

Soil erosion from water is caused and influenced by long and steep slopes, intense rainfall, and raindrop impact, when there is a lack of protection from plant, crop residue, or mulch covers. Concentrated flows and increased velocity of water increases sediment load and increases erosion potential. During construction activities, exposure of subsoil and compaction result in decreased aggregate stability and impaired infiltration, leading to increased runoff and soil erosion.

Soil erosion from water has several forms, including:

Sheet - uniform removal of soil without the development of conspicuous water channels;

Rill - removal of soil through the cutting of numerous small but conspicuous water channels or tiny rivulets; and

Gully - removal of soil through the formation of relatively large channels or gullies cut into the soil by concentration of runoff characterized with evidence of "head" cutting.

Soil movement can also occur from streambank, shoreline, and landslip erosion which is the mass movement of soil from slides or flows.

When certain soils are kept unvegetated during construction they can be susceptible to wind erosion, which may have local offsite affects. Mulching or temporary and permanent vegetative covers can alleviate this problem.

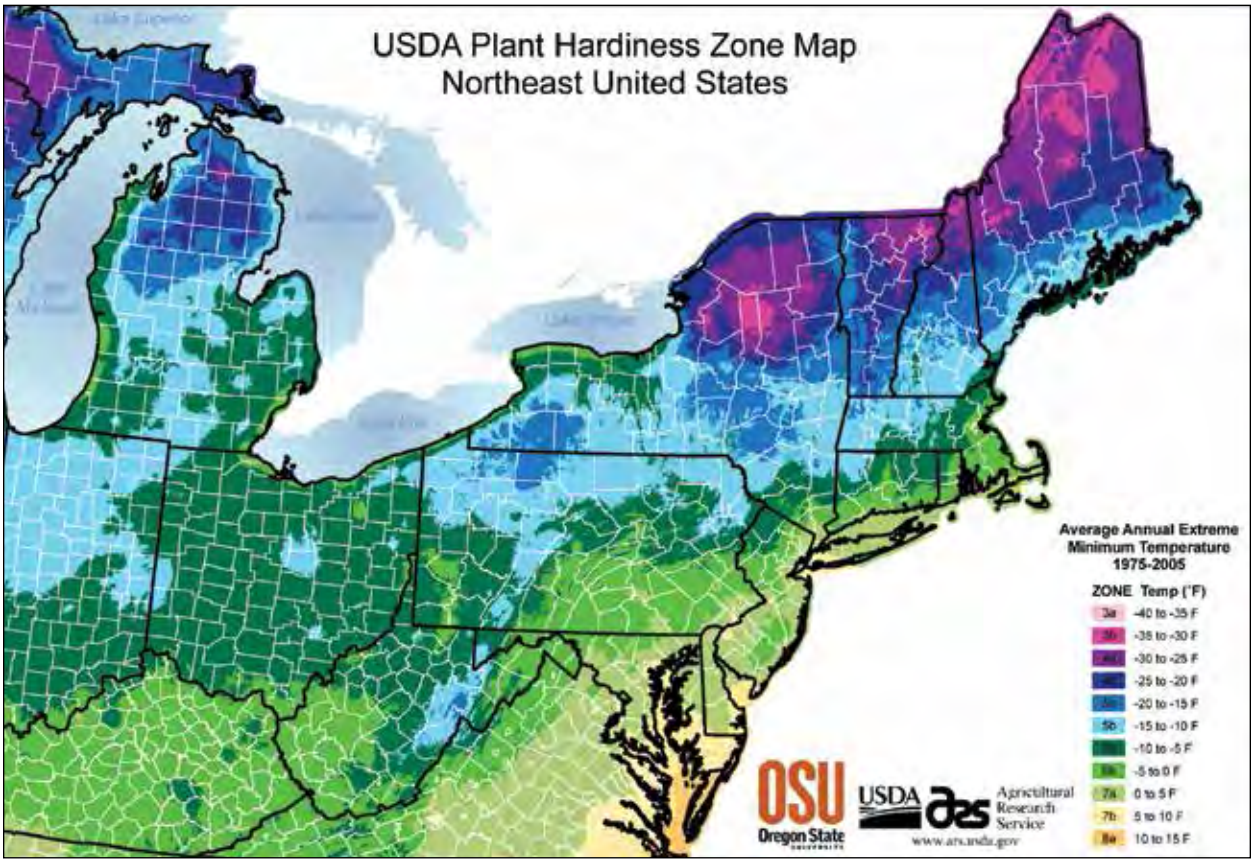


Figure 1b. The USDA Plant hardiness zone map is used when selecting plant material for conservation plantings.

Excess Water Management and Erosion Control

Excess water should be diverted around the site to a safe outlet or conveyed through the site via a waterway or steep slope conveyance structure (Figure 1c). In some cases, subsurface flows will need to be intercepted by drainage tiles. Control of excess water is important to avoid soil erosion and to facilitate revegetation efforts and to prevent subsequent site damage. Erosion can be reduced and revegetation efforts enhanced by grading and terracing to allow more infiltration and to breakup long slopes reducing concentrated flow areas. Refer to the NRCS Engineering Field Handbook for guidance on water control practices.

Geology

Because geology strongly influences soil development and the characteristics of soil, understanding the geology of an area is important in making critical area treatment decisions. Parent material for soil development comes from underlying rock strata or is transported from other locations. The soil parent material affects the pH, water-holding capacity, the nutrient content, and retention capacity of the soil. This is particularly true of the subsoils often found on disturbed sites. Bedrock and changes of soil texture at various depths need to be addressed early in the grading and revegetation process.

Geology contributes to the shape of the landform. The slope of a site influences the erosion process through water movement across the landscape. The local hydrology may contribute to mass wasting of soils, and can result in critical stabilization problems.

Figure 1c. Diversion ditches and waterways are used to divert concentrated runoff away from new seedings and to direct water to a safe outlet.

The East region includes several mountain ranges including the Appalachians, Adirondacks, Green and White ranges, and the Catskills. Glaciations over the northern states have created complex till soils and the marine and Great Lakes' influences have created sedimentary deposits and coastal sands.

Mining activity is a primary contributor of critical areas to the region. There are active and abandoned sand and gravel pits, coal, salt, copper, zinc, lead, iron, titanium, limestone, slate, and hard rock mines in the region, all requiring revegetation. Exposed minerals from mining activity such as sulfur and iron, which result in the formation of acid materials when oxidized, need to be addressed early in grading and revegetation plans.

Soils

A site that is to be disturbed due to construction should have a plan in place that minimizes the impact to the soil and vegetation occurring outside the project's construction limits. This is typically done by clearly marking and adhering to boundary markers like sediment fencing. Areas that lie within a construction site should have a plan for utilizing topsoil based on a survey conducted to determine the depth and quality of the topsoil. Topsoil within the construction site should be removed and safely stockpiled for later redistribution on the site. Soil is the medium in which seeds germinate and roots grow and the ability to assess soil conditions is critical in selecting successful vegetative options. Soil amendments and treatments can mitigate some soil problems. Moving topsoil from another site is often done to replace the original topsoil layer. However, replacing topsoil with that taken from another site is expensive both economically and environmentally, and creates two degraded sites. Furthermore, for some applications, the selection of plant materials adapted to degraded sites may make replacing the topsoil unnecessary.

Critical area plantings are often planned for sites where soils have been degraded. The site may be considered critical due to the removal of topsoil with only the subsoil remaining. In some cases, the site consists of a mixture of subsoil from the site or subsoil and other material brought in having little or no topsoil. Subsoil material is often infertile, weak in structure, very low in organic

matter, higher in bulk density, and more acid or basic than the associated topsoil.

Compaction is another serious issue facing disturbed soils. It occurs when soil particles are pressed together. Soil can be compacted by heavy machinery through the destruction of soil structure or may be naturally occurring in some subsoil. Compacted soil or subsoil may be exposed during construction which then becomes the planting medium. As soil particles are squeezed together, soil density increases and pore space for air and water are reduced. Lack of pore space in the soil reduces water intake and movement throughout its layers. Compaction also limits root growth and the biological diversity of the soil. Bulk density is a measure of soil compaction and is expressed as a weight per unit volume of soil, (grams/cm^3). Root penetration, gas exchange, and soil water movement becomes inhibited as bulk density rises to 1.4 g/cm^3 in clays and up to 1.7 g/cm^3 in sands. Refer to Chapter 4, Table 4a for information regarding bulk density limits on root growth for specific soil textures. Mechanical treatment and soil amendments may be necessary to reduce the bulk density/soil compaction so vegetation can be established.

These problems are compounded when organic matter content is lost by topsoil removal. Soil compaction can lead to low infiltration rates, increased erosion and stormwater runoff, decreased water quality from polluted runoff, and increased flooding. Despite soil limitations, plant materials need to be successfully established to stabilize the site and initiate recovery.

Soil samples from degraded sites can be analyzed for organic matter, macro- and micronutrients, bulk density (compaction), soil particle size distribution, pH, and toxic elements or compounds. The mailing containers and information for collecting soil samples for basic soil tests can usually be obtained from local cooperative extension offices or directly from labs. Site history is important in determining which tests are needed. Using soil tests to determine fertilizer rates can avoid over application, reducing costs and preventing excess fertilizer from polluting streams and/or groundwater. The results of the soil analysis can assist in selecting plants that are appropriate for the site.

Information on the identification and properties of soils as they occur in the landscape can be found online on the USDA-NRCS Web Soil Survey website or by consulting with your local NRCS office.

Soil texture is an important soil characteristic that drives crop production and field management and is important when planning conservation or critical area plantings. The textural class of a soil is determined by the percentage of sand, silt, and clay. Soils can be classified as one of four major textural classes: sands, silts, loams, and clays. A soil textural triangle developed by the USDA is used to determine soil textural classes from the percentages of sand, silt and clay in the soil, more information can be found on the NRCS Soils Education web page. Soil texture determines the rate at which water drains through a saturated soil, for example water moves more freely through sandy soils than it does through clayey soils. Once field capacity is reached, soil texture also influences how much water is available to the plant as clay soils have a greater water-holding capacity than sandy soils. Soils also differ in their susceptibility to erosion (erodibility) based on texture as a soil with a high percentage of silt and clay particles has a greater erodibility than a sandy soil under the same conditions.

Soil particle size distribution is important because soil nutrient and water-holding capacity is related to the percentage of soil fines (those particles that can pass through a 200-mesh sieve, .0029-inch opening). As the percentage of soil fines drops below 20 percent, the site becomes increasingly droughty and devoid of nutrients. In sand and gravel mine reclamation, where percent fines by weight passing a No. 200 sieve is less than 15 percent, warm season grasses should be used to assure a persistent cover. Soil's physical workability is also diminished in heavy clay soils.

Soil drainage class identifies the natural drainage condition of the soil. Drainage classes provide a guide to the limitations and potentials of the soil for field crops, forestry, range, wildlife, and recreational uses. The soil drainage class roughly indicates the degree, frequency and duration of wetness which are factors in rating soils for various uses. The eight natural drainage classes are: (1) Excessively drained; (2) somewhat excessively drained; (3) well drained; (4) moderately well drained; (5) somewhat poorly drained; (6) poorly drained; (7) very poorly drained; and (8) subaqueous. For a detailed description of each of these soil drainage classes refer to the NRCS Soil Survey Manual, Chapter 3, Examination and Description of Soils.

Soil acidity or alkalinity is measured by the pH logarithmic scale (1 = acidic to 14 = basic, with 7.0 being

neutral). This is a measure of the balance between hydrogen ions (positively charged) and hydroxyl ions (negatively charged) in the soil water solution. Good soil conditions fall in the pH range of 6.0 to 7.0; fair conditions range from 5.5 to 7.5. Plant problems begin when pH is below 5.5 and above 7.5. The pH scale is logarithmic, so a change from 5.0 to 6.0 is not a change by a factor of 1, but a factor of 10; and a change of pH from 5 to 7 is a factor of 100, therefore a pH of 5.0 is 10 times more acidic than a pH of 6.0. Eastern soils tend to be acidic, but disturbed sites' pH can be above 7.5 if the parent material and subsoil is alkaline. The soil texture and mineralogy affect the soil pH and its response to lime. Chapter 4 covers the use of lime and sulfur to amend the soil's pH.

Macro- and micronutrients are present in healthy soils and these enable plants to thrive. Disturbed sites can be very nutrient depleted as the organic matter and A/B horizons containing most of the nutrients available to plants are lost. Fertilizers and organic supplements can be applied after a soil nutrient analysis is performed. Though micronutrients occur in soils at very low concentrations, their absence is detrimental to some plant species. Legumes are particularly sensitive to a lack of boron, yet only 1 to 2 pounds per acre may be all that is needed. The use of fertilizers and soil amendments are covered in Chapter 4.

Soil Quality

Soil quality as defined by the Soils Science Society is "the capacity of a specific kind of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation" (Karlen et al., 1997). Soil quality integrates physical, chemical and biological processes, and the interactions between them. The chemical properties of soil are analyzed with a nutrient soil test. Soil can also be tested to determine the status of the soil's biological and physical parameters that are often limiting to plants on disturbed sites. Cornell University provides soil quality testing information at the Cornell University Soil Health website.

Soil organic matter (SOM) is the most important indicator of soil quality and productivity. It consists of a complex and varied mixture of organic substances and is found in the highest percentage in the topsoil. Soil organic matter is the decomposed plant and animal residue in soil. Humus is amorphous organic matter that has reached a point of stability and if undisturbed is resistant to further decay. Decayed soil organic matter acts like a sponge, absorbing up to six times its weight in water. In sandy soils, water held by organic matter often makes the difference between seeding failure or success. A pound of stabilized organic matter can have five times as much cation-exchange capacity (CEC) as a pound of clay, resulting in organic matter holding five times the nutrients for plants to use. Soil organic matter increases the formation and stability of soil aggregates (very small clumps of soil particles) that are held together by moist clay, organic matter, organic compounds or fungal hyphae. These aggregates reduce soil surface crusting and increase soil porosity. The infiltration and water-holding capacity of the soil is increased providing increased water availability for plants and less erosive runoff. Erosion may be more serious after organic matter loss due to reduction of infiltration and soil aggregate stability, increased bulk densities, changes in soil pH, reduction in nutrient and water-holding capacity, and reduction in the buffering of toxic substances. It is important to disturb as little of the site as possible. The use of compost, manures, and approved biosolids can be used to improve organic matter composition of a site. Improving the organic matter on a site facilitates the establishment and growth of plants that, in turn, provide organic matter to soils.

Soil biology consisting of fungi, bacteria, and other micro and macro invertebrates are important for the decomposition of soil organic matter and nutrient cycling. Fungi that colonize fresh organic matter enmesh soil particles forming cross-links that assist with the stabilization of soil particles into aggregates. Soil bacteria are also involved in soil aggregation, producing compounds called polysaccharides that are useful for holding soil particles together. Plant roots occupy larger volumes of well-aggregated soil.

Arbuscular endomycorrhizal fungi (AMF) form symbiotic relationships with many plants. These fungi need to be associated with living plant roots, benefiting by obtaining soluble organic nutrients from the root cells. The plant benefits from the enhanced absorption of water and soil mineral ions such as phosphorus by the plant. The association with AMF makes the plants more stress tolerant. AMF will not be present on sites that are stripped

to subsoils and if not re-introduced these will return very slowly. The use of donor topsoil containing beneficial bacteria and fungal parts can be advantageous to plant success and to site stability. However, donor topsoil may also introduce soil pathogens and weeds not currently on the site. Topsoil saved from the work site and stockpiled is most desirable. It is also worth noting that native plant nurseries commonly add arbuscular endomycorrhizal fungi inoculants into the soil mixes used to grow plants. The use of commercial AMF inoculants for direct application of disturbed sites is not supported by research and is not a widely accepted practice.

Timing of Planting

For critical area and conservation planting it is extremely important to follow time of seeding and planting recommendations to facilitate success. Specific seeding and planting date requirements by species and planting stock are covered in Chapter 4 and Appendix 4a. Seeding dates are given in ranges and are based on averages within plant hardiness zones; timing will vary based on elevation, aspect, position on slope, and location within PHZ. For construction projects, seeding should be done as construction is complete or at intervals during construction. Temporary seeding and mulching are important tools to reduce sedimentation and other offsite impacts and to allow for permanent vegetation establishment at the appropriate time of year. Engineered approaches for critical area stabilization have strict completion dates. This same approach should be enforced when a vegetative approach is used as it has become commonly acceptable to plant beyond recommended dates. Since it takes the same or less time, money, energy, and effort to plant during the optimum time of year; do not plant outside of the appropriate time. Planting outside of the optimum times often leads to failure of the planting with resultant costs of replanting and potential environmental degradation. Weather plays a major role in determining the proper time to plant within or near the optimum planting window. There is usually a fairly short period of time during which planting conditions are at or near optimum. To miss this period can mean the difference between success and failure.

Present and Proposed Use

The choices made in stabilizing a site are influenced by the intended use of the site. The intended use of the site should be based on the inherent site limitations. The site must be capable of supporting the planned use and that use must not interfere with the stabilization of the site. If pedestrian or vehicular use of the site will be permitted, traffic patterns and water control should be planned and designed to minimize erosion potential. Control of unauthorized off-road vehicle activity must be in place before installation of plants for critical area treatment. Damage from unauthorized access during the establishment period will undermine the success of the planting. Select plants to meet the existing or future site use to minimize or facilitate future maintenance. The planting of trees and shrubs where appropriate can blend structures or the site into the surrounding landscape.

Chapter 2
Plant Materials

The information in this section highlights the attributes of plant groups and individual plant species. It starts with the grasses, a group that is employed on almost every site. Characteristics of the plants mentioned in this chapter, including seeds per pound, are provided in tables in Appendices 2c–2k. This information is compiled from the PLANTS Database, *Native Trees, Shrubs, and Vines for Urban and Rural America* (Hightshoe, 1987), and other sources referenced in the tables. A legend for the definition of the plant characteristics from the PLANTS Database is provided in Appendix 2b. In the online version, the tables in Appendices 2 (c, d, e, g, and h) are linked to the PLANTS Database for photographs and additional information. For additional detail for many of the plants listed refer to the Plant Fact Sheets found on the USDA-NRCS National Plant Materials website and the PLANTS Database.

Grass Information

Grasses are the most useful group of plants for critical area treatment and conservation plantings. Due to the large number of species and their range of variability in form and function, almost all plantings include grasses either as the primary or temporary cover to serve until the site is dominated by other species. Perennial grasses are typically an early component of any natural revegetation/succession following annuals. Some perennial grasses are able to tolerate droughty, infertile soil conditions while accumulating organic matter over time allowing for the colonization of woody species.

In the Northeast, grasses are native to areas with soils, hydrology, or other environmental conditions unsuitable for succession to climax forests. These include riverbanks and flood scoured flood plains repeatedly disturbed by high velocity water and ice flows, as well as sandy, droughty, or shallow soils of pine barrens and oak openings. Warm season grasses from climax grassland communities migrated eastward after the last glaciation period to occupy these areas. In wetland areas, native cool season grasses, sedges, and rushes evolved and occupy these sites.

The introduction from Europe of many cool season grasses for use as forage contributed to the large colonization and naturalization of grasses in areas that were and are deforested for agricultural, housing, and other uses. In most cases without management, these areas will return to the forest-type climax community of the physiographic region. Cool season grasses used for critical area stabilization and turf have their origin from these introduced cool season grasses. These include ryegrass, tall fescue, red fescue, bromegrass, red top, and others.

Grasses exist in a diverse range of conditions and have adapted, in part, by evolving their physiology, anatomy, and morphology. Typically they are divided into two groups; warm and cool season grasses. We can take advantage of some major distinctions that occur between warm season and cool season grasses. These two grass types are distinguished by their photosynthetic systems. The cool season grasses are known as C_3 grasses and the warm season grasses are known as C_4 grasses. These names are based on the three and four carbon atoms present in the first product of carbon fixation produced from their different photosynthetic systems. These photosynthetic pathways (each with associated anatomical differences) explain why they grow more efficiently during warm or cool temperatures. The more extensive and fibrous root characteristics of warm season grasses also increase their drought tolerance compared to cool season grasses. Recognizing these differences is vital in understanding how to use these types of grasses to achieve environmental goals.

As the names imply, cool season grasses grow most efficiently when air and soil temperatures are cool, between 55°F and 75°F; and warm season grasses grow most efficiently when temperatures are between 65°F and 95°F. Once established, warm season grasses are generally more efficient than cool season grasses at producing above and below ground biomass and have deeper, more robust root systems. When soils are deep and unimpeded, the fibrous root systems of warm season grasses can extend 6 to 8 feet. The fibrous root system is effective in mining nutrients and moisture from large areas. This allows them to tolerate low fertility levels and droughty conditions (Figure 2a). Warm season grasses are higher in fiber compared to cool season grasses due to differences in their leaf anatomy and lower leaf to stem ratio. This makes warm season grass less palatable and digestible to livestock and wildlife. Most commonly used cool season grasses originated in Eurasia, while most of the warm season grasses used are native to North America.

Figure 2a. Warm season grasses, like switchgrass, have deep, fibrous root systems, which adapt them to droughty conditions and low fertility soils.

Figure 2b. Rhizomatous roots of grasses like those of prairie cordgrass, serve an important erosion control function.

It is important to understand what happens during plant establishment (seed germination and plant development) when choosing a cool season or warm season grass. Cool season grasses typically germinate rapidly, producing a higher proportion of leaf area compared to roots during the initial establishment period. Warm season grasses tend to have more seeds that are dormant, and which germinate slowly. Warm season grass seedlings produce a higher proportion of roots compared to leaves during the initial establishment period. These survival strategies favor cool season grasses for fast establishment and warm season grasses for tolerance of less favorable droughty conditions. Introduced cool season grasses keep their growing point low and close to the soil, tolerating close mowing or grazing.

Native warm season grasses elevate their growing point to about 6 inches above the soil surface, and are injured by repeated close mowing or grazing. Consequently, it is recommended that warm season grasses mowed during the growing season be mowed no shorter than 6 to 8 inches above the ground as this also facilitates rapid regrowth. A comparison chart of warm and cool season grasses is provided in Appendix 2a.

Roots serve an important function for vegetative stability and erosion control (Figure 2b). Both the cool and warm season grass groups include species that are bunch forming, rhizomatous, and stoloniferous. Bunchgrasses, like hard fescue, maintain individual plants that increase in basal diameter as time passes. They are generally more compatible with wildflower mixtures than are the rhizomatous and stoloniferous grasses. Bunchgrasses can have very extensive root systems providing excellent erosion control. Seeded at high enough seeding rates, they create a tightly woven sod providing excellent cover. Rhizomatous grasses, like smooth bromegrass, produce creeping underground structures called rhizomes that generate additional plants at nodes from the original plant. These create sod-like growth and fill in open surface space faster than bunchgrasses. As a result, they may crowd out other species over time. Stoloniferous grasses, like

bentgrass, produce surface runners that also result in new plants forming from the original plant. Some grasses are both rhizomatous and stoloniferous.

Important Grasses for Critical Area Plantings

The descriptions presented cover the most important grass traits. For additional detail and cultivar information, refer to Plant Fact Sheets, on the USDA-NRCS National Plant Materials website, the PLANTS Database, the National Turfgrass Evaluation Program website, and Grass Varieties in the United States, Agriculture Handbook No. 170. Some land grant colleges have data on varietal comparisons of grasses and legumes used for forage production. Many of these forage grasses and legumes are used for critical area seedings and conservation cover. There are several excellent identification guides available online which are listed in the reference section.

Introduced Cool Season Grasses

Appendix 2c provides plant characteristics from the PLANTS Database for introduced cool season grass species useful for conservation seedings.

Group A. Very fast germination and growth

Annual ryegrass (*Lolium multiflorum*) is one of the fastest grasses for quick cover and it tolerates moderately wet soils (poorly drained) and light shade. Annual ryegrass is a bunchgrass noted for its extensive root system. It should be used alone for temporary cover for one growing season as the rapid germination and early growth of this species can hinder the growth of more valuable grasses in mixes. Due to its low cost, the percentage of annual ryegrass in some commercial mixes is overly high and these mixes should be avoided. Annual ryegrass may become weedy if allowed to reseed when used as a cover crop in annual crops or used as a nurse crop in some commercial mixes.

There are two kinds of annual ryegrasses Italian and Westerwold, within these groups there are many cultivars. The Westerwolds are true annuals that will produce a large amount of biomass/forage in one season, produce seed and then die. Annual ryegrass cultivars of both kinds are either diploid or tetraploid (with twice the number of chromosomes). Tetraploid cultivars tend to yield more grass, but may be less winter hardy. Italian types, either diploid or tetraploid, will express biennial behavior, and will not go to seed until after a vernalization (overwintering) period. The Westerwold type is considered the weedier of the two because when sown in the spring it can go to seed during the growing season. Use cultivars tested for superior winter hardiness when seeding over the winter in plant hardiness zones (PHZ) 4 and north.

Cereal rye (*Secale cereale*) is a small grain crop plant which may be used for temporary cover. It is very winter hardy and capable of late season establishment compared to other winter annual grains and grasses. It grows on heavy clay and sandy soils. It tolerates acid and lower fertility soils more than the other winter grains with a pH range of 4.5 to 8.0. 'Aroostook' rye is the cultivar of choice, allowing for planting about one week later in the fall than other cereal rye cultivars. Aroostook has exceptionally fast, robust spring growth and flowers earlier than most varieties.

Perennial ryegrass (*Lolium perenne*) is a bunchgrass, short lived in PHZ 5a and north and may have excessive mortality the first winter. You should select cultivars that have been specifically tested in your region. Plant types are available as lower growing turf or taller vigorous forage varieties. Lower growing turf varieties provide less competition in mixes when grown with slower growing but longer lived cool season grasses. Use forage varieties where wildlife cover is an objective. Newer turf varieties may contain endophytic fungi that enable the grass to tolerate temperature and moisture stress better than forage types. To avoid impeding the growth of other species use no more than 10 to 15 percent by weight of perennial ryegrass in the mix.

Redtop (*Agrostis gigantea* = *Agrostis stolonifera*) is longer lived, tolerates a lower pH and is much hardier than perennial ryegrass. Redtop is low-growing, rhizomatous, rapid spreading, and tolerates both dry and wet soil conditions. It has tiny seeds, about 5 million seeds per pound, which germinate rapidly and care is needed to allow for even distribution. Usually no more than 1 to 3 pounds per acre are included in cool season grass mixtures to avoid competing with the other species in the mix. Redtop is typically sold as common seed, since there are very few cultivars available.

Group B. Intermediate germination and growth

Fine fescues consist of creeping red, chewings, sheep and hard fescues. With the exception of creeping red, these are all bunchgrasses. They are all cold hardy, with medium seedling vigor and growth rate. They are more drought and shade tolerant than most cool season grasses and are adapted to well-drained, low fertility, acidic sites. They do not tolerate high traffic areas like athletic fields and intense summer heat can cause plants to go dormant. They may provide a low maintenance alternative in areas with low traffic. Their low fertility and water requirements, slow growth, relatively low height, and fine texture result in less mowing than other cool season grasses.

Due to their slow establishment compared to other cool season grasses, however, they should not be used alone in areas requiring immediate erosion protection. Weed control is needed especially in the establishment year. Do not fertilize in the year of a spring seeding unless weeds are controlled because fertilizer will generally result in heavy weed growth. Fine fescues perform well in wild flower plantings or in orchards because they are not overly competitive. They are usually planted in mixes with other grasses. Plant improvement programs have been incorporating endophytic fungi associations to improve insect and stress resistance.

Never mow fine leaf fescues in the summer during conditions of heat or drought stress. For stands dominated by the fine leaf fescues, a minimum cutting height of 2.5 inches is tolerated, but a 3.5 inch or higher cutting height is preferred. Mowing may be as infrequent as once or twice per month spring and fall, and once monthly in summer. Regardless of cutting height, always wait until it rains before mowing fine leaf fescues in the summer.

- **Creeping red fescue** (*Festuca rubra*) also referred to as red fescue, is a fine-leaved, low-growing rhizomatous fescue that spreads slowly by short rhizomes but faster than tall fescue. Red fescue establishes relatively faster than the other fine fescues. Red fescue has good tolerance to shade and many soil conditions, from well-drained to somewhat poorly drained soils as well as sandy and acid soils. It is drought resistant, once established, but requires ample moisture for establishment. Where shorter grasses are desired, this species is very useful in both turf and critical area treatment plantings. Red fescue has the most wear tolerance and seedling vigor of the fine fescues.

- **Chewings fescue** (*Festuca rubra* ssp. *commutata* = *Festuca rubra* ssp. *fallax*) is a fine-leaved bunchgrass. It is shade and drought tolerant, slow growing, and tolerates low fertility, sandy, and acidic soils. Chewings fescue is more erect and shade tolerant than red fescue, but not as wear or drought tolerant as other fescues. It can be mowed to 1.5 inches; shorter than other fine fescues, which prefer a minimum mowing height of 2.5 inches. Chewings fescue can be used in mixes for low maintenance turf with reduced mowing regimes, although it has more seed heads than the other fine fescues.

- **Sheep fescue** (*Festuca ovina*) is a fine-leaved, short, stiff bunchgrass with bluegreen leaves. It is shorter than hard fescue and capable of large root biomass production on soils with good drainage. Sheep fescue is slow to establish, but tolerates low fertility and sandy soils. It is the most drought tolerant of all the fine fescues and is compatible with wildflower plantings on drier sites. However, sheep fescue is the least recommended for any turf application, due to lack of general aesthetics.

- **Hard fescue** (*Festuca ovina var. duriuscula* = *Festuca brevipila*) is a fine-leaved grass similar in appearance and use to red fescue. It is a bunchgrass, capable of high root biomass on well-drained soils. Hard fescue is adapted to well-drained, infertile soils, is not overly competitive and is slow to establish. Hard fescue is more tolerant of drought, heat, and low fertility than chewings and creeping red fescue but not as drought resistant as sheep fescue. It is characterized as having dark green fine leaves that are broader than sheep fescue. Hard fescue is the most salt tolerant of the fescues. It should not be mowed as low as the other fescues. This grass is preferred for perennial cover crops in orchards, Christmas tree plantations, and wildflower plantings because of its non-rhizomatous growth habit and its disease and stress resistance. Hard fescue stays green longer under stress than other fine fescues.

Kentucky bluegrass (*Poa pratensis*) is the classic lawn grass for the Northeast, and is sometimes included in critical area treatment mixes where turf is desired and suitable care will be provided because it can not tolerate the stresses found at most critical sites. Kentucky bluegrass is rhizomatous, but very shallow rooted and grows best on well-drained loams or clay loams rich in humus and on soils with limestone parent material. It needs large amounts of nitrogen during its active growth stages. Kentucky bluegrass is intolerant of drought, excessive flooding, high-water tables, and poorly drained soils. It prefers sunlight but will do well in light shade with ample moisture and nutrients.

Orchardgrass (*Dactylis glomerata*) is a shade tolerant bunchgrass. Compared to other cool season grasses it has a dense, relatively deep root system. It does not grow well in areas with high water tables but is moderately tolerant to drought. Orchardgrass is an excellent grass for grazing and hay and is not typically used in mixes for critical area stabilization due to its clumping habit. It is used in grass-legume mixes for nesting, brood rearing, escape and winter cover in upland wildlife conservation plantings. Due to its shade tolerance and suitability for wildlife it is sometimes used in mixtures for seeding logging roads and landings.

Tall fescue (*Festuca arundinacea* = *Schedonorus phoenix*) is a bunchgrass that spreads by seed and short rhizomes. It is widely adapted, easy to establish and long lived under harsh conditions and mistreatment. It has a more rapid growth rate and higher seedling vigor than red fescue. Tall fescue is controversial because older forage varieties and newer turf varieties contain an endophytic fungus that helps the grass tolerate stress. The presence of the fungus reduces forage quality and may affect wildlife. For critical area treatment, the endophyte infected varieties are more tolerant of degraded soils and should be considered for high priority areas. Many cultivars exist, including narrow bladed turf types as well as the forage types. There are endophyte free varieties like 'Kentucky 32', and endophyte friendly varieties such as 'MaxQ', which are less virulent, and could be used in less degraded areas or where there is concern for wildlife. Due to its wider leaf and color it is noticeable when it volunteers into bluegrass lawns.

Group C. Relatively slow germination and growth

Smooth bromegrass (*Bromus inermis*) is a strongly rhizomatous grass that is slow to establish and difficult to plant due to its large, papery seed. Once established, it is tolerant of dry conditions although not as drought tolerant as some of the other fine fescues. Smooth bromegrass is best adapted to cooler climates and is generally hardier than tall fescue or orchardgrass. It is not tolerant of shade. This plant may become weedy or invasive in some regions or habitats.

Reed canarygrass (*Phalaris arundinacea*) is a strongly rhizomatous grass that is slow to establish, tolerates both wet and dry soils, and had been recommended for wet spillways and drainage ditches. Reed canarygrass is considered invasive in wetland ecosystems where it displaces native species and is difficult to control once established. In some states this species may appear on state legislated invasive or noxious weed lists thus restricting it from being used. Although seed of this species may still be commercially available and may still be recommended by some land grant colleges for forage, consider using other species appropriate for your critical area sites.

Native Cool Season Grasses

There are not many native cool season grasses in the Northeast that have been used or improved for critical area plantings. This is probably due to the adequate performance of introduced cool season species for critical area stabilization and some of the natural limitations of the native species which include poor seed production, awned seed, very small seed size, and low seedling vigor and plant growth. There are possibilities for improvement in plant performance by selection and breeding. In some instances, the use of non-improved germplasm or ecotypes will satisfy the objectives of the planting while maintaining genetic diversity. Some of the native species commercially available for upland plantings will be reviewed below. Appendix 2d provides plant characteristics from the PLANTS Database for some native cool season grass and sedge species useful for conservation seedings.

Fringed brome (*Bromus ciliatus*) is a long-lived bunchgrass with a moderate growth rate, seedling vigor, and foliage density. Fringed brome attains a height of up to 4 feet.

It does not tolerate excessively wet or dry soils. Fringed brome is shade tolerant and compatible in mixes with wildryes, warm season grasses, or wildflowers, providing some early cover, but will not persist in warm season grass plantings. Fringed brome occurs in a variety of habitats including woodlands, forest openings, thickets, grasslands, shrublands, prairies, meadows, marshes, bogs, fens, and stream and lake margins.

Wild bromegrass (*Bromus latiglumis*) is a bunchgrass that grows from 1 to 4 feet tall, has dense foliage, and is shade and moisture tolerant, usually found in alluvial thickets or woods.

Wildryes (*Elymus spp.*) are upright, moderate- to short-lived bunchgrasses. They are predominately self-pollinating but have a small percentage of cross-pollination and can hybridize between species. They do not tolerate frequent or low mowing. They can be compatible with native warm season grasses and wildflowers in seed mixes. Wildryes have awns similar to warm season grasses and are best seeded using a drill with a native grass hopper with picker wheels to ensure good seed distribution. Follow additional procedures described in Chapter 4 for chaffy (awned) seeds. There are other wildryes such as bottlebrush grass (*E. hystrix*) and silky wildrye (*E. villosus*) that can be added for diversity but are not as vigorous as those mentioned below.

- **Canada wildrye** (*Elymus canadensis*) is a short-lived bunchgrass with large, coarse leaves, which grows to a height of 2 to 3 feet. Canada wildrye is adapted to coarse-textured sandy, gravelly, or rocky soils and is more tolerant of droughty, poor fertility soils than Virginia wildrye. For this reason it may be used in mixtures with warm season grasses on sandy soils and critical areas for early establishment and cover until the warm season grass species are established. It also has the most tolerance to saline conditions of the wildryes. The awned arching seed heads of Canada wildrye are showy, and the grass is often used for decorative planting near roadside rest areas and in parks. It has high seedling vigor and rapid growth but is not overly competitive with other grasses. It is somewhat tolerant of shaded sites. If seeded early in the spring, this wildrye frequently produces seeds in the establishment year, providing a food source for wildlife. Canada wildrye is naturally found growing on dry to moist or damp, often sandy or gravelly soil on prairies, dunes, streambanks, ditches, roadsides, and disturbed ground, or in thickets and open woods near streams.

- **Virginia wildrye** (*Elymus virginicus*) is a robust but relatively short-lived grass, 2 to 3 feet in height, with a seed head more upright than Canada wildrye. It is tolerant of poorly drained to well-drained soils. It grows in full sun to shade; however, plants that grow in sunlight tend to be more robust than those that grow in shade. It has moderate drought tolerance, seedling vigor, and growth rate. Virginia wildrye grows in moist to damp to somewhat dry soil, mostly on bottomland or fertile uplands, in open woods, thickets, areas with tall forbs, or weedy sites.

- **Riverbank wildrye** (*Elymus riparius*) is a bunchgrass with a moderate lifespan. It is taller than other wildryes reaching heights of up to 4 to 5 feet at maturity. It has high seedling vigor and moderate growth rate. It is more tolerant of acid soils than the other wildryes, and can survive down to a pH of 4.5. It is tolerant of poorly drained to well-drained soils. It is has low drought tolerance and good shade tolerance. Riverbank wildrye grows in moist, usually alluvial, and often sandy soils in woods and thickets, usually along larger streams and occasionally along upland ditches.

The following cool season grasses have very fine seeds, having from 2 to 8 million seeds per pound requiring very low seeding rates in mixes to avoid species from dominating the stand or used in low rates due to their expense. Care should be taken when calibrating and mixing the seed to assure even distribution.

Canada bluejoint (*Calamagrostis canadensis*) is a long-lived grass with a rhizomatous root system obtaining heights up to 5 feet. It is useful for wetland restoration and for stabilizing shorelines and streambanks. This seed is very expensive due to low seed yields, and the very fine seeds (3.8 million seeds per pound) are difficult to process. The seed has fine hairs, which should be processed during seed cleaning, to improve flow in some seeding equipment. Over time this grass can produce dense stands in open areas, although it has medium

seedling vigor and spreads slowly. It is typically used as a minor component in wetland mixes. It is tolerant of poorly drained soils and tolerates a pH as low as 3.5. Canada bluejoint may be established vegetatively by plugging using 3,500–7,000 plants per acre. Canada bluejoint can be found in a wide variety of environments including meadows, open woods, wet thickets or swamps, marshes, bogs, ditches, and the margins of streams and lakes.

Autumn/Upland bentgrass (*Agrostis perennans*) is a grass similar in habit to redtop. It has rhizomatous spreading capability and grows up to 3.5 feet. This species is tolerant of anaerobic soil conditions and has low drought tolerance. It is relatively short lived with low seedling vigor and intermediate shade tolerance. Autumn bentgrass has a very fine seed, 8 million seeds per pound and although the seed is not expensive, it should be seeded at very low rates in mixes to prevent it from dominating the stand. It is more tolerant of shade and moisture than rough bentgrass, from which it differs in its later flowering, leafier culms, and its basal leaves that usually wither by anthesis. Autumn bentgrass grows along roadsides and in fields, fens, woodlands, and periodically inundated streambanks.

Rough bentgrass (*Agrostis scabra*) is a bunchgrass reaching heights up to 2.5 feet. It has very fine seeds (5 million seeds per pound). Since it is a bunchgrass it is less competitive than the autumn bentgrass or redtop. It has low shade, drought and acidic soil tolerances. Rough bentgrass grows in a wide variety of habitats, including grasslands, meadows, shrublands, woodlands, marshes, and stream and lake margins, as well as disturbed sites such as roadsides, ditches, and abandoned pastures. It has a more open panicle compared to upland bentgrass.

Fowl bluegrass (*Poa palustris*) is a bunchgrass reaching heights up to 4 feet. It has intermediate shade tolerance and medium seedling vigor. Fowl bluegrass is moderately tolerant of wet areas and has low drought tolerance. It has fine seeds (2 million seeds per pound) and is reasonably priced. However it should be seeded at very low rates in mixes so as not to dominate the stand. Fowl bluegrass is widespread in cool-temperate, boreal, riparian, and upland areas where it is used for soil stabilization and waterfowl feed.

Sedges (*Carex spp.*)

There are a few sedges which stand out as having better than average seedling vigor and reasonable cost that have potential for direct seeding in conservation plantings. There are many more which are available in the seed trade as well as those sold as plugs. Sedges are typically planted as plugs at a spacing of 1.5 to 3.0 feet on center. Some sedges, which are relatively inexpensive as seed and are listed in some commercial mixes, are fringed nodding sedge (*C. crinita*), nodding sedge (*C. gynandra*), shallow sedge (*C. lurida*), Blunt broom sedge (*C. scoparia*), Squarrose sedge (*C. squarrosa*), and Fox sedge (*C. vulpinoidea*). Other sedges and some rushes (*Juncus spp.*), bulrushes (*Scirpus spp.*), bur reed (*Sparganium spp.*), and forbs are included in commercial wetland mixes with the sedges. Most sedge seed and the above genera prefer stratification prior to germination and lighted/surface conditions for optimum germination. The Sparganium spp. prefers to be seeded as soon as they are ripe or stored in moist peat and kept frost free.

Wetland indicator status for the sedges are noted below. Obligate (OBL) wetland indicator status indicates that the plant occurs almost always (estimated probability 99 percent) under natural conditions in wetlands. Facultative Wetland (FACW) wetland indicator status indicates the plant usually occurs in wetlands (estimated probability 67 to 99 percent), but is occasionally found in non-wetlands.

Fox sedge (*Carex vulpinoidea*) is a sedge with a bunch growth form with a mature height of 3.2 feet and fine foliage texture. It has medium anaerobic tolerance, intermediate shade tolerance, and low drought tolerance adapted to all but very coarse textured soils. It is a long-lived sedge with medium seedling vigor and a moderate growth rate after establishment. Fox sedge has fine seed with approximately 1.3 million seeds per pound and is reasonably priced, making it a major component in mixes targeted for wet areas. Fox sedge seeds well without stratification. Fox sedge has OBL wetland indicator status and is found near water on moist, open ground in swamps, prairie swales, lowland forests, wet ditches, ravines, and along the edges of marshes, springs, lakes, and ponds. Sometimes this robust sedge can spread aggressively, especially in disturbed areas with reduced competition from other plants.

Shallow sedge (*Carex lurida*) is a sedge with a bunch growth form, a mature height of 3.2 feet and a porous

foliage texture. It has medium anaerobic tolerance and low drought tolerance and is adapted to all soil textures. Shallow sedge has an intermediate shade tolerance and tolerates acid soils. It is a long-lived sedge with medium seedling vigor and seed spread, and a moderate growth rate after establishment. Shallow sedge has larger and fewer seeds per pound than the other sedges described in this section (250,000 seeds per pound). Similar to fox sedge, shallow sedge has an OBL wetland indicator status and is found in wet meadows, marshes, seeps, shores of ponds, lakes, and streams, open swamp forests, and ditches, mostly in acidic, often sandy soils.

Blunt broom sedge (*Carex scoparia*) is a sedge with a bunch growth form, a mature height of 1.5 to 3.0 feet and medium foliage texture. It has high anaerobic tolerance and is drought intolerant, adapted to all soil textures except coarse soils. Blunt broom sedge has high shade tolerance and tolerates acid soils. It is a long-lived sedge with low seedling vigor and seed spread with a moderate growth rate after establishment. This sedge has fine seed with approximately 1.3 million seeds per pound. Blunt broom sedge has a FACW wetland indicator status and is found in wet prairies, marshes, fens, gravelly seeps, margins of ponds and streams, and roadside ditches.

Native Warm Season Grasses

Unless noted, the grasses listed are native to the northeastern U.S., have extensive, deep fibrous roots, and are bunchgrasses or have short rhizomes. These grasses have high seed dormancy and are slow to germinate and establish. They are long lived, tolerant of droughty and acid to alkaline conditions, but not to shade. Native warm season grasses can be hardy to plant hardiness zone (PHZ) 3, depending upon site specifics and chosen ecotypes/cultivars. Flowering dates will also vary by ecotypes with northern ecotypes flowering sooner than southern ecotypes. These are mostly tall grasses providing outstanding wildlife cover and critical area stabilization on droughty sites like gravel mines. Cultivars have been, and continue to be, selected for increasingly defined areas of use, especially for biomass energy. There is also non-cultivar, source-identified germplasm available from some seed suppliers. Many of the cultivars and ecotypes developed in the Midwest do very well in the East when moved along latitudinal lines. Many warm season grasses have populations or cultivars with differing chromosome numbers (cytotypes) such as tetraploids and octoploids. It is very important to collect or screen for the same cytotype, when assembling seed for increase, or developing ecotypes, in order to maintain good seed production. Appendix 2e provides plant characteristics from the PLANTS Database for warm season grass species useful for conservation seedings. Appendix 2f provides a list of warm season grass cultivars, their state of origin and plant hardiness zones of adaptation.

Group A. Smooth seeded species that can be planted with common drills

Switchgrass (*Panicum virgatum*) has evolved into two main ecotypes. The upland types, which are predominately octoploid, are typically found in northern regions. They are semi-decumbent to erect and fine stemmed, the cultivar 'Cave-in-Rock' is an example of this type. The second ecotype is the lowland types, which are predominately tetraploid, are typically found in southern regions and are less hardy in PHZ 5a and north. They are erect and stiff stemmed, the cultivar 'Kanlow' is an example of this type. Switchgrass is a stiff-stemmed, smooth-seeded, hardy, and widely used bunchgrass which grows to a height of 6 feet. It should be included in small amounts in all critical area treatment plantings where warm season grass is desired. Switchgrass seed weight has been reported to be from 259,000 to 389,000 seeds per pound varying by cultivar, cytotype, and geographic area of origin. It has excellent standability, having the ability to withstand snow and winds, remaining upright over winter. Its good winter standability provides good late winter and early spring cover for wildlife. Some ecotypes have aerenchyma tissue in the roots allowing air to travel down the roots providing more tolerance to wet conditions. Switchgrass grows in tall grass prairies, especially mesic to wet types where it is a major component of the plant community, and on dry slopes, sand, open oak or pine woodlands, shores, riverbanks, and brackish marshes. For nesting cover for upland birds, limit its percentage in the mix to 10 percent by weight. Switchgrass can be used for biomass production, wildlife habitat, gravel pit reclamation, and as a wind barrier.

Coastal panicgrass (*Panicum amarum* var. *amarulum*) is similar to switchgrass in morphology and winter standability but has better seedling vigor. The good seedling vigor helps with initial stand establishment;

however it is not hardy north of PHZ 6. It can be used as an annual in colder climates to provide initial temporary cover in mixes with other warm season grasses on sand and gravel pits. Coastal panicgrass grows faster than most warm season grasses and is usually found on the coastal dunes, wet sandy soils, and the margins of swamps, along the Atlantic Ocean and the Gulf of Mexico from Connecticut to northeastern Mexico.

Deertongue (*Dichanthelium clandestinum*) is wide leaved and shorter than most warm season grasses with a height up to 2.5 feet. It is tolerant of wet sites as well as drier conditions and is one of the more acidic soil tolerant species useful in mixes for reclaiming coal mine sites. Deertongue usually grows in semi-open areas in damp or sandy woodlands, thickets, or on banks.

Eastern gamagrass (*Tripsacum dactyloides*) is a very large, robust bunchgrass with wide leaves and thick stems that can reach a height of 7 feet. Eastern gamagrass is one of the earliest warm season grasses to break dormancy in the spring. Eastern gamagrass is not as drought tolerant as the others in this group but is moderately tolerant of anaerobic conditions and some genotypes have aerenchyma tissue. Eastern gamagrass has robust root systems that have been reported to penetrate clay pan layers. Eastern gamagrass has livestock forage quality and palatability superior to most warm season grasses, although in the Northeast it is more typically used for wildlife food and cover. A distant relative of corn (*Zea mays*), eastern gamagrass has corn-sized seed requiring deeper seeding depth than other warm season grasses, and should therefore be seeded separately with a corn planter to get proper depth. The seed must be cold stratified or fall planted (late) as establishing a solid stand can be difficult due to the hard seed coat and seed dormancy. Due to the high cost of the seed and the low number of seeds per pound (7,000) the seeding recommendations historically are typically lower than adequate to produce a good stand for forage production. In the Northeast it's native range is within PHZ 6 and south although it will tolerate lower temperatures to PHZ 5a when seeded.

Sand lovegrass (*Eragrostis trichodes*) is a short-lived bunchgrass native to the Midwest but not to the Northeast. This grass provides rapid germination on gravel mine sites as a companion in mixes with eastern native grasses. It has high seedling vigor and 1.6 million seeds per pound. It does not tolerate very acid soils.

Purpletop (*Tridens flavus*) is a short-lived relatively short bunchgrass, obtaining a height of 2.5 feet. It is well adapted to shallow, droughty, infertile soil tolerating a pH to 4.5. It has moderate leafiness with only moderate erosion protection. It has high seedling vigor and spreads naturally by seed. Purpletop grows in old fields and open woods and is hardy to PHZ 6 and south.

Group B. Chaffy seeded species that require de-bearding or specialized drills

Big bluestem (*Andropogon gerardii*) is a bunchgrass with short rhizomes that slowly expands the basal cover, with a height of 6 feet or more. It is best adapted to moist, sandy or clay loams but also occurs in dry or shallow soils. It is not tolerant of heavy clays, extremely wet bottomlands, deep sands, high salinity, or high lime. Big bluestem is slightly more drought tolerant than indiangrass and switchgrass, but less than little bluestem. Like switchgrass, it is one of the major grasses of the tallgrass prairie and eastern native grasslands and should be a major component in most warm season grass seed mixes on well-drained soils. Big bluestem is more palatable to livestock than switchgrass and indiangrass, but not as much as eastern gamagrass.

Sand bluestem (*Andropogon hallii*) is native to the Midwest and is a special use species in the Northeast on very droughty, highly disturbed sand and gravel mines. Sand bluestem has a stature similar to big bluestem but with better seedling vigor. It has a moderate lifespan, and in mixtures with natives this grass adds diversity and increases cover while being able to tolerate impoverished conditions.

Indiangrass (*Sorghastrum nutans*) flowers later in the spring than other warm season grasses originating from similar geographic regions. Indiangrass grows 3 to 5 feet tall and has conspicuous showy inflorescence of a golden brown color. There are some blue ecotypes useful for ornamental purposes. Indiangrass has short rhizomes and grows best in deep, well-drained floodplain soils. The winter standability of its dormant vegetation ranks second to switchgrass for winter cover. Indiangrass was also a major component of the tall grass prairie and is a major

component in most warm season grass mixes. Indiangrass grows in a wide range of habitats, from prairies to woodlands, savannahs, and scrubland vegetation.

Little bluestem (*Schizachyrium scoparium*) is a short-statured bunchgrass obtaining heights up to 3 feet. It is more drought tolerant than big bluestem, switchgrass, and indiangrass. On very dry sites, this species should be included in the grass mix and is exceptionally compatible with forbs due to its shorter growth. Little bluestem may have problems competing with other warm season grasses and weeds on fertile loam soils. It grows preferentially on sites with pH 7.0 but tolerates ph 5.2 to 8.4. Little bluestem is the most difficult to de-awn making the use of native seed hoppers almost mandatory. Habitats include hill prairies, gravel prairies, sand prairies, black soil prairies, clay prairies, scrubby barrens, rocky slopes of thinly wooded bluffs, sandy savannas, hilltop glades (limestone, sandstone, or shale), sand dunes, gravelly areas along railroads, and abandoned fields.

Sideoats grama (*Bouteloua curtipendula*) may be considered non-native or rare in some of the Northeast states. It is a short statured grass 1.5 to 3 feet tall, and slightly rhizomatous. It is moderately drought tolerant adapted to shallow soils and tolerates moderately alkaline conditions. Sideoats grama is found on rocky open slopes although it is moderately tolerant to shady conditions. It is being considered for use in mixes with other short warm season grasses for ground nesting bird habitat, but like little bluestem it does not compete well with tall warm season grasses and weeds on fertile silt loam soils.

Group C. Vegetatively established species

American beachgrass (*Ammophila breviligulata*) is a leafy, spreading, strongly rhizomatous grass, producing annually up to 100 stems per clump under cultivation. This cool season perennial grass species will spread up to 6 to10 feet annually through subsurface rhizomes. It will grow 2 to 3 feet tall, tolerating annual over-topping accumulations of sand up to a foot deep. A widely available sand dune stabilizing plant, it is also useful in very droughty materials such as mine wastes and gravels. An Atlantic coastal cultivar "Cape" is widely available; however, this cultivar should not be planted along the Great Lakes region due to the occurrence of a Great Lakes subspecies.

Prairie cordgrass (*Spartina pectinata*) is one of the earliest of the warm season grasses to emerge in the spring and can grow up to 6 feet tall. Prairie cordgrass's tolerance to very poorly drained soils is attributed to the aerenchyma tissue in its roots, which allows for air to transfer down through the roots into saturated soil conditions. It is adapted to very poor to well-drained soils, is very rhizomatous and under moist conditions is capable of spreading 10 or more feet annually. It tends to form solid stands on wet spots contained within drier sites, but will also grow into relatively dry areas. Prairie cordgrass may be planted by seed but, is usually vegetatively planted due to the cost of the seed, poor seed quality and low seedling vigor. Prairie cordgrass grows in marshes, sloughs, and flood plains as well as gravelly roadsides, being a common constituent of the ice-scoured zones in the Northeast.

Saltmeadow cordgrass (*Spartina patens*) is a warm season grass which grows up to 3.5 feet tall. This species is hardy to PHZ 6 and south. It is rhizomatous, extending about 1 foot per year and growing immediately above the intertidal zone, commonly forming solid stands. Saltmeadow cordgrass is used for shoreline protection and tidal marsh restorations. It is often utilized for stabilizing levees and dunes near beaches and on barrier islands. This grass is adapted to a wide range of soils from coarse sands to silty clay sediments with pHs ranging from 3.7 to 7.9. Saltmeadow cordgrass will tolerate irregular inundations with up to 35 parts per thousand of salinity. It is usually one of the dominant components of coastal salt marshes, frequently extending from the dry, sandy beach above the intertidal zone well up into the drier portions of the marshes.

Smooth cordgrass (*Spartina alterniflora*) is a tall, coastal, warm season grass which grows to a height of 6 feet. This species, depending on ecotyope, can be hardy to PHZ 5 and south. Rhizomes spread about 2 feet per year forming solid stands. It is utilized extensively for erosion control along shorelines, canal banks, levees, and other areas of soil water interface. Smooth cordgrass is an effective soil stabilizer used on interior tidal mudflats, dredge-fill sites, and other areas of loose and unconsolidated soils associated with marsh restoration. This grass can be found growing on sandy aerobic or anaerobic soils with a pH range from 3.7 to 7.9 and is able to tolerate regular inundations with up to 35 parts per thousand of salinity.

Smooth cordgrass is found on muddy banks, usually of the intertidal zone, in eastern North America.

Legumes and Wildflowers (Forbs)

Legumes

Legumes are exceptionally valuable conservation plants that are used in crop rotations, for cover cropping, or as a component in perennial grass and legume mixes for forage, buffer, or wildlife plantings. They are also a useful component in critical area plantings. The trait of greatest value is their ability to fix nitrogen, through a symbiotic association with certain rhizobia bacteria. These bacteria convert atmospheric nitrogen gas to ammonia nitrogen, a form usable by the legume plant. This relationship occurs in specialized root tissue called nodules. As the roots and leaves die and decompose, the organic nitrogen is released in the soil and is mineralized into forms that are available for uptake by other plants. The availability of this nitrogen for associated grass plants is valuable in the degraded soils of most critical areas. Stronger grass growth and greater biomass builds soil organic matter and improves erosion control. Increased organic matter results in enhanced plant recruitment and succession. The potential for long-term nitrogen fixation is important due to the lack of maintenance fertilizer applications for most conservation or critical area plantings. Some legumes have taproots, which grow deep into the soil and have the potential over time to provide channels for other plant roots. These taproots are thicker than the fibrous roots of grass, are usually fewer in number, and do not form the dense intertwined root systems of grasses. A close look at solid legume stands on sloping soils often reveals that soil erosion is occurring under the mat of surface vegetation. Legume leaves have a low carbon to nitrogen (C:N) ratio and will quickly degrade in the fall providing less cover than grasses over winter.

Soil stabilization and soil quality improvement are the primary considerations in critical area treatment, but the wildlife value of many legumes can be important. The first use of revegetated land is often by wildlife for cover and/or food. The enhancement of the growth of grasses and other plants from the nitrogen supplied by legumes can be a key factor in providing dense cover for wildlife. Many legumes provide nutritious forage or browse for wildlife. A few have negative food value and are avoided by some classes of wildlife. Most legumes are excellent sources of nectar and pollen for honey and native bees. Legumes do not have a wide tolerance of soil pH, and are generally not adapted to wetter sites. Critical areas may have one or more of these conditions. If legumes are in the mix, the soil should be amended with lime to the level recommended for the legume. For conservation practices such as diversion ditches and waterways with adequate drainage, the grass and legume seedings can be harvested each year as a hay crop. Most common agricultural legumes are not native to North America. Typically legumes need to be seeded several weeks earlier than cool season grasses when planted as a late summer seeding. This provides the legume adequate time to become established and better survive the winter freeze and thaw cycles.

Inoculating Legumes

When planting legumes the seed must be inoculated with the appropriate inoculum (rhizobia bacteria) to enhance nitrogen fixation. It is not a good practice to rely on native rhizobia. Inoculating legumes is especially important on low pH and disturbed soils where most if not all of the existing rhizobia have been lost. Each legume genus or species requires a specific species and strain of bacteria. For example, there is not one inoculant that will work for all legumes (i.e. clovers, alfalfa, birdsfoot trefoil, or vetches). When possible you should purchase seed pre-inoculated and use within one year or re-inoculate. Always store in a cool dry environment. Some pre-inoculated seed is encapsulated in a clay or limestone coating having fewer seeds per pound requiring an increase in seeding rate. If re-inoculating encapsulated seed use a small amount of vegetable oil as sticker. When purchasing inoculums for treating seed consult with your supplier and read the package label for application instructions to select the correct inoculum for the legume being planted. Inoculants need to be stored in a refrigerator or cool, dry environment until used and must be checked for the expiration date, as expired inoculants will not provide acceptable amounts of bacteria. Inoculation should take place immediately before the seed is planted to protect the inoculant from drying out, falling off the seed, and dying. Moistening the seed with a very small amount of water, augmented with a sugar or corn syrup solution (1:4) or a commercial sticking agent will help the inoculant stick to the seed. While in the field, keep inoculants out of direct sunlight and overheated vehicles, and they should never be stored or transported on the dashboard of a vehicle

Seed planted by hydroseeding should include quadruple the recommended inoculation rate in the tank mix.

Hard Seed Coats

Hard seed is a form of seed dormancy, typically found in legumes, that prevents the initiation of germination by inhibiting moisture from entering the seed. This is more often a problem with native legumes where breeding has not occurred to reduce the percentage of hard seed. Legume seeds may last a very long time in storage and in the soil seed bank. Hard, shiny, impermeable seed coats protect the seeds but also hinder germination. Seed can be scarified to allow the seed to absorb water and initiate germination. Methods involve a sanding treatment for small lots, or carefully processing with hammer mills for larger lots. The seed coat must be scratched or cracked without destroying the seed. Sulfuric acid is another scarification technique that may be done commercially. Native legumes, sometimes require either or both scarification and cold stratification. Cold stratification is the treating of seed by soaking in water (imbibing) then subjecting them to a period of cold temperature just above freezing for 4 to 8 weeks or longer depending on the species.

Check the germination vs. hard seed percentages before purchasing, and in some cases you may want to increase the seeding rate to compensate for an excessive amount of hard seed. The seed dealer may have seed lots with better germination, or may scarify the seed prior to shipment. Scarified seed should be planted within the year purchased and not held over for planting the following year, since germination will decline more quickly with scarified than unscarified seed. In some situations, an optimum seed mix contains both seeds that are ready to germinate and some that are hard. Hard seeds provide a hedge against bad weather during the establishment year. More information on dormant and hard seed is provided in Chapter 3, "Reading and Understanding Seed Tags and Seed Tests".

Introduced Legumes

Introduced legumes species such as crown vetch (*Coronilla varia*), yellow sweetclover (*Melilotus officinalis*), flat pea (*Lathyrus sylvestris*), and perennial pea (*Lathyrus latifolius*) were recommended in the past but are now considered invasive and/or problematic. These species may appear on state legislated invasive or noxious weed lists thus restricting them from being used. Although seed of these may still be commercially available, consider using other introduced legumes or other species appropriate to your critical area site. Do not use any introduced cool season legumes outlined in the section below in combination with wildflowers for pollinator habitat improvement, as they will outcompete most wildflowers. It is possible to use a mix of introduced legumes alone for that purpose. Appendix 2g provides plant characteristics from the PLANTS Database for introduced cool season legume species useful for conservation seedings.

White clover (*Trifolium repens*) is a long-lived perennial, attractive to insects and grazing mammals. White clover can be classified in three general groups: small, intermediate, and large. The small white clover is a naturalized form and is not usually produced commercially. Most of the white clovers sold in this country as common white clover belong to the intermediate group. Dutch white clover is considered in the intermediate group. The large group is usually referred to as the Ladino type and is more useful for forage and erosion control work because it is taller and more robust than the common Dutch type. New pasture varieties are also useful for critical area seedings. To be sure of what type you are purchasing buy certified seed. White clover has smaller seed than most clovers with 776,000 seeds per pound. It can tolerate wetter and slightly more acid soils than red clover. Very dry soils limit the establishment of white clover; it is less drought tolerant than birdsfoot trefoil but more than red clover. The extreme stoloniferous growth of the Dutch type can restrict the establishment of other more slow germinating species so keep its seeding rate low. The Dutch type is low growing and marketed for use in lawns and is also useful in mixes with low growing grasses for perennial cover crops in orchards and tree nurseries. Do not use in mixes with wildflowers due to its over competitiveness.

Red clover (*Trifolium pratense*) is a short-lived perennial, which is not adapted to poorly or excessively drained soils. It has limited usefulness for critical area seedings due to its short life span and early seedling vigor overwhelming slower-growing and longer-lived species. Frost seeding into existing stands of grass (typically overgrazed pastures) is a useful management technique; however, the existing vegetation must be suppressed prior to frost seeding. Red clover is also used as a cover crop, interseeded into corn

or wheat to produce nitrogen for the succeeding crop. Red clover has intermediate shade tolerance making it useful for planting with shade tolerant grasses on log landings. It is also an excellent forage plant for wildlife. Common seed is satisfactory although newer varieties may have greater persistence.

Alsike clover (*Trifolium hybridum*) is more tolerant of poorly drained soils than white or red clover. It is taller than white clover but is relatively short lived and is not tolerant of shade. It has medium seedling vigor. Alsike clover can cause health problems in horses when grazed such as photosensitization and liver damage; in both cases it takes a few days or weeks of grazing to produce the symptoms. Alsike-induced photosensitization has also been reported among other grazing animals.

Birdsfoot trefoil (*Lotus corniculatus*) is a moderately long-lived perennial. It has a well-developed, branching, tap-like root with side roots near the soil surface. It has greater pH tolerance and longevity than the clovers or alfalfa on critical areas, but is slower to establish with less seedling vigor than most other forage legumes. Its wider adaptation to moist conditions makes this a useful plant; however, birdsfoot trefoil is potentially weedy and is incompatible with plantings of native wildflowers and warm season grasses. If used in mixes for critical area plantings it is compatible with introduced cool season grasses. The taller upright types should be used in mixes for critical area planting. 'Viking' or 'Norcen' are useful older cultivars, while 'Pardee' is a variety resistant to fusarium wilt providing better persistence. When cut during the growing season it should be cut at a height no lower than 4 inches.

Native Legumes

Native legumes are more useful for conservation plantings such as wildlife and pollinator enhancement than for areas with critical erosion problems. Native legumes are typically more expensive than introduced forage legumes. They are also typically slower to establish, have more dormancy and hard seed than introduced legumes. It is very important to scarify seed when the seed test indicates a high percentage of hard seed as well as to inoculate with species-specific inoculum. Most of the native legumes are rated as low to medium in nitrogen fixation capacity. Most cool season introduced grasses are too competitive to be grown with native legumes except for the non-rhizomatous fine fescues. Short stature warm season grasses and wildryes at moderate seeding rates are more compatible in mixes with native legumes.

Native ecotypes are available from some commercial sources. The availability and price of local ecotypes may vary by year due to seed production constraints, some seed of these species may originate from the Midwest. As discussed in Chapter 3, be cognizant as to whether the seed is being priced as bulk seed or pure live seed (PLS). Get a cost estimate based on PLS when the recommendations are given in PLS. Some native legumes have had some selection or breeding for traits important to gardeners, and these cultivars are being increased for the horticulture market. Care should be taken to avoid ordering this seed if restoration is the primary purpose. Some of this seed may be listed in native seed catalogues. Not all legumes listed in this guide are native to every state in the Northeast. Those interested in native plantings are referred to the Natural Heritage Botany Program in your state or the Nature Serve Explorer website as discussed in the "Native Plant" section of Chapter 1. Appendix 2h provides plant characteristics from the PLANTS Database for some native legume species useful for conservation seedings.

Canadian Milkvetch (*Astragalus canadensis*) has a wide geographical distribution, therefore the origin of the seed source should be identified. It is a short lived (3 to 4 years) rhizomatous species with a height up to 3.5 feet. It prefers moist sites and is not recommended in dry upland soils. Canada milkvetch is used for erosion control, forage, restoration projects, and wildlife habitats. It is also a source of nectar for bumblebees, and its seeds are eaten by wild turkeys. This species should be planted at a rate of up to 0.25 PLS pounds per acre in mixtures with other native plants. The flowers are creamy and greenish white, blooming in late summer. Scarification improves seed germination.

Yellow wild indigo (*Baptisia tinctoria*) is native to most of the Northeast. Heights range from 1 to 3 feet with a moderate growth rate and relatively low nitrogen fixation potential. Yellow wild indigo prefers sun, is drought tolerant, and prefers well-drained soils. It is very slow to establish and does not spread vegetatively. Native ecotypes of this species are expensive. There are Midwest cultivars, developed for the horticulture market, which cost

somewhat less. This species has variants with blue, white, yellow, and cream-colored flowers. Seed germination improves with scarification or in combination with cold stratification.

Blue false indigo (*Baptisia australis*) is considered native to parts of the Northeast and may be useful due to the larger biomass and nitrogen produced. It has a height ranging from 3 to 4 feet. Compared to wild indigo, blue false indigo is long lived in its natural habitats and produces a heavy taproot that extends several feet. It is slow to establish and large seeded, with 22,000 seeds per pound. This plant does not grow well in shaded habitats. It prefers gravelly, sandy or well-drained loamy soils and can withstand prolonged droughts. Baptisias have been used as ornamentals in gardens throughout the Northeast for many years. Seeds need scarification or in combination with cold stratification for improved germination.

Partridge pea (*Chamaecrista fasciculata*) is a reseeding summer annual with golden-yellow flowers in late summer that grows 1 to 2 feet tall. The origin of the seed is critically important because southern origin ecotypes will not mature and set seed in the shorter northern summers. It grows best in full sunlight, has low water requirements and a lower pH limit of 5.0. It occurs naturally on disturbed sandy soils where a seed source exists and remains for several years through prolific reseeding. Usually a component of a wildflower mix, it should be seeded at very low seeding rates due to its prolific reseeding ability and potential to compete with other desirable species.

Illinois bundleflower (*Desmanthus illinoensis*) is native to the southern portion of the Northeast and Mid-Atlantic. This species grows 3 to 4 feet tall and is multistemmed with bipinnately compound leaves. It thrives on medium textured soils and is tolerant of most soil types except very coarse sands and heavy clays. Illinois bundleflower has good drought tolerance and tolerates pH 5 to 8. It establishes easily, spreads from seed, and has high seedling vigor. In its natural habitat, Illinois bundleflower is normally found in association with tall, native warm season grasses. Seed germination is improved by scarification.

Tick trefoil (*Desmodium* spp.) is native to the East and includes showy tick trefoil (*D. canadense*) and panicledleaf tick trefoil (*D. paniculatum*) with showy ticktrefoil being the most widely available from native seed providers. These plants grow erect up to 3.5 feet and have a strong taproot. Showy tick trefoil prefers full sun and tolerates a range of soil acidity. It is highly adaptable and will grow on a wide range of soil textures from coarse sands to fine clays, preferring loamy soil, as long as adequate moisture is present. This species has good seedling vigor and spread. It is very competitive and is capable of competing with the tall warm season grasses. For this reason, it should be limited to no greater than 1 lb/ac in mixes. Seed and foliage are valuable to wildlife. The seed is contained in a hairy pod that is Velcro-like in attaching to clothes or fur. Scarification improves seed germination.

Roundhead lespedeza (*Lespedeza capitata*) is native to the Northeast, has stiff, erect stems that are 2 to 4.5 feet tall and is multi-stemmed. It is drought tolerant, preferring well-drained soils. Roundhead lespedeza is shade intolerant and is slow to establish. It is a desirable component in short-statured warm season grass mixtures, providing moderate nitrogen input. Germination is improved with scarification. Other lespedeza that are currently available or have shown seed production potential are hairy bush clover (*L. hirta*), slender lespedeza (*L. virginica*), and wandlike bush clover (*L. intermedia*). The hairy bush clover is similar in height to the roundheaded. The other two are 1 to 3 feet in height.

Sundial lupine (*Lupinus perennis*) is native to the Northeast and grows to a height of 1 foot. There are ecotypes that are specific to very sandy areas and have a coexistence with the Karner blue butterfly, an endangered species. It is important to use only this local ecotype in areas such as the Albany Pine Bush. This ecotype is difficult to establish in its natural droughty habitat. The roots are strong and deep, making the moving of older established plants difficult. This lupine is large seeded with 18,800 seeds per pound. The seed should be scarified then soaked in water overnight and treated with species specific inoculums prior to planting. This genus is native throughout the western United States and there are many cultivars on the market. Another type of lupine, big leave lupine (*Lupinus polyphyllus*), is sometimes sold widely in the horticulture trade. This species is much larger than *L. perennis* and should not be used as a substitute.

Wild Senna (*Senna hebacarpa*) is native to the Northeast but is considered rare in some states, so should not be used indiscriminately. Ranging in height from 3 to 5 feet with a single stem, this species tolerates moderate shade and drought, prefers pH near neutral, and tolerates some wetness. Wild senna has 23,000 seeds per pound and has relatively good seedling vigor but is slow growing and takes a couple of years to get established. Seed germination is improved with scarification. Additional information for this species is provided in the wildflower table in Appendix 2i.

American and Carolina Vetch (*Vicia* spp.) are both viney plants with slow vegetative spread and low seedling vigor adapted to well-drained sites. They are drought tolerant and shade intolerant and have 32,800 seeds per pound. American vetch is not dominating like introduced vetches, but adds interest and diversity to native seed mixes. Seed production and availability is limited or unavailable at present.

Other Native Wildflowers (Forbs)

There is increasing interest in enhancing habitat for pollinators, other beneficial insects and wildlife. For pollinator enhancement seedings (Figure 2c), at least 75 percent of the mix as measured in PLS seeds/ft^2 should be wildflowers with the remainder being non-aggressive grasses. To add diversity and color to other wildlife plantings 15 percent of the mix as measured in PLS seeds/ft^2 should be in wildflowers. Like the native legumes, the cost of most wildflower seed is high and establishment can be challenging. The availability and prices will vary yearly due to seed production constraints. Additional information about purchasing wildflower seed is given in Chapter 3. As mentioned in the "Native Legumes" section, get a cost estimate based on PLS when the recommendations are given in PLS. When planting native forbs follow the precautions mentioned in the "Native Plants" section of Chapter 1 about determining native, threatened, and endangered status. Some of the species mentioned in this guide are not native to all states in the Northeast.

Figure 2c. Wildflowers can add pollinator enhancement, aesthetics and diversity to warm season grass wildlife plantings. Photo by Eric Mader, Xerces Society.

Appendix 2i provides a table of 60 "native" wildflowers and some of their attributes useful when planning wildflower plantings. This table was compiled from many existing tables, the PLANTS Database and other sources listed in the table and reference sections. The table lists the following information: pollinator ranking, plant hardiness zone, bloom time and color, height, wetland indicator status, pH range, sun light needs, vegetative spread, seedling vigor, seed spread, seeds per pound, a cost estimate and ease of establishment rating. Some of these factors like height and flowering time will vary depending on the ecotype planted and the site conditions such as soils and plant hardiness zone. An estimated cost per species is given based on 2011 prices, which are subject to change, but gives some guidance when developing mixes. A conservation seed calculator was developed so that mixes could be created based on percentage of the mix by seeds per square foot as well as by pounds per acre. The seed calculator and a couple of sample mixes are provided in Appendix 2j. The calculator will be available on the USDA-NRCS Big Flats Plant Materials Center, Website. Techniques for the establishment of wildflowers are provided in Chapter 4.

Woody Plants: Trees and Shrubs

The initial climax vegetation in the vast majority of the Northeast was forest. Historically, grasslands and savannahs were a small component that occurred where droughty soils and/or fire management by Native Americans hindered woody plant recruitment. Critical area treatment can be planned to progress rapidly to woody plant dominance or to retain a grass-based cover. The planting of trees and shrubs can facilitate the transition to a woody cover and improve species diversity. Trees and shrubs are often planted for other conservation objectives such as riparian buffers for water quality benefits, forestry, erosion control on streambanks, as well as food and cover for wildlife and carbon sequestration. Windbreaks are planted for wind erosion control, air quality, snow control (Figure 2d), and energy conservation.

A table of tree and shrub characteristics is given in Appendices 2k and 2l respectively, which is adapted from *Native Trees, Shrubs, and Vines for Urban and Rural America* (Hightshoe, 1987), and the USDA-NRCS PLANTS Database 2012. This table will be helpful in selecting trees and shrubs for conservation plantings. The information provided includes plant hardiness zone, plant height, flood and shade tolerance, drought resistance, growth rate, longevity, soil compaction, rooting type, density, pH and disease, and insect resistance. Some plants may be rare or non-native in some states in the Northeast. Refer to the Nature Serve Explorer website and Natural Heritage Botanist for native distribution and conservation status of the species for the state in which the planting will be conducted.

In addition to these tables there are many excellent texts and websites with species descriptions of trees and shrubs that are available and listed in the reference section. References include: Silvics of Forest Trees of the U.S. and the U.S. Forest Service, Fire Effects Information database.

Figure 2d. Windbreaks can act as living snow fences to control snow accumulation.

Temporary Cover, Smother Crops, and Nurse Crops

The use of summer and winter annual grasses, legumes, forbs, and short lived perennials have many applications for conservation plantings. They can be used as temporary covers to protect sloping land from soil erosion, provide some weed control and produce organic matter for improving soil quality. They can be used as smother crops to assist with tillage, with or without herbicides to help break up weed cycles. Cover crops with high C:N ratios like mature cereal grain or warm season annuals may temporarily tie up nitrogen so the addition of supplemental nitrogen fertilizer may be warranted. These species can be used as nurse crops at reduced rates to provide quick cover and some limited weed control while the permanent species are getting established. Some of these species can help remediate soil compaction. The seeding rates will vary depending on the purpose of their

use. For critical area applications the use of dormant seeding or mulch is sometimes used instead of temporary late fall annual grain cover crop seeding. This is done to avoid having to kill and incorporate residue in the spring. Dormant seedings as discussed in Chapter 4 will require some follow up reseeding. Some temporary covers need to be managed to prevent them from going to seed and becoming a weed problem for the following seeding or providing too much residue to interfere with seedbed preparation. Avoid using species of temporary covers where they could be alternative hosts or refuges for insect pests and diseases of nearby crops. Descriptions for some of the species not covered elsewhere in the document are given below. Seeding rates, seeding depth, seed weight and recommended seeding dates are given for species used for temporary cover in Appendix 4b.

Cereal Rye (*Secale cereale*) is a winter cereal grain which can be planted later in the season than all other temporary covers. The crop prefers well-drained soils but will tolerate poorly drained soils. It grows in heavy clay and sandy soils. It also tolerates acid and lower fertility soils more than the other winter grains, tolerating a pH of 4.5 to 8.0. Cereal rye has a well-developed fibrous root system that reduces leaching of soil nitrates. The top growth provides soil cover and suppresses weeds; however, its productive spring growth can be difficult to manage in the spring. Cereal rye has been reported to have allelopathy in which compounds in its plant tissues and root exudates inhibit germination and growth of weed seeds. However these same compounds can have an impact on small seeded crops if planted immediately following incorporation of cereal rye residue.

Oats (*Avena sativa*) is a spring grain crop which produces abundant biomass when planted in early August to the beginning of September. Oats will winter kill providing less of a management problem in the spring than cereal rye but will not recycle nitrogen. The residue is quick to degrade in the spring offering limited soil erosion protection. It can be used as a nurse crop with cool season species and at reduced rates with warm season grasses and forbs. Oats grow in well-drained, fine sandy loam to clay soils, and tolerate a pH of 5 to 8.5.

Wheat (*Triticum aestivum*) is a spring or winter annual so appropriate cultivars should be selected for the intended purpose. Wheat requires slightly higher soil temperatures to germinate and grow than cereal rye so should be seeded at least a week earlier. Wheat prefers well-drained silt loam or clay loam soils but will grow in fine sandy loam to clay soils and tolerates a pH of 5 to 8.5. Wheat produces less biomass in the spring than cereal rye so there is less biomass to kill and interfere with seeding in the spring. Wheat is susceptible to Hessian flies, so if this is a concern in your area wheat should not be grown in the fall prior to the Hessian fly free date to avoid spreading this insect pest to nearby wheat production fields. Rye, barley and triticale are not damaged by Hessian flies. Triticale is a winter grain hybrid between rye and wheat.

Barley (*Hordeum vulgare*) is a spring or winter annual not typically grown as a winter cover north of PHZ 7 since young seedlings will undergo winterkill at temperatures around 15° F. Therefore use spring cultivars and plant in the spring in the Northeast unless you plant early and can tolerate some winterkill. It prefers well-drained loamy soils and is more drought tolerant than the other cereal grains. It is less tolerant to acid soils, requiring a pH of 6 to 8.5. It is very tolerant to salinity and more tolerant of alkalinity than the other cereal crops. It is a host to barley yellow dwarf virus which can also infect wheat, but it is not susceptible to Hessian fly.

Foxtail millet (*Setaria italic*) is a warm season annual grass also referred to as German millet, which can be used as a smother crop while not producing as much biomass as sorghum-sudangrass. Foxtail millet forms slender, erect and leafy stems that can vary in height from 2 to 5 feet. Foxtail millet should be cut before seed matures to avoid becoming a weed problem. Foxtail millet grows well on well-drained loamy soils with a pH of 5.5 to 7.5. It will not tolerate water-logged or extreme droughty coarse sandy soils. Plant in a well prepared firm seedbed after soils have warmed and first flush of weeds can be controlled by tillage. Foxtail millet is a carrier for the wheat spindle streak mosaic and the wheat curl mite which transmits the disease. Although cultivars are not seriously bothered by these pests, they can serve as an over-summering host.

Teff (*Eragrostis tef*) is a warm-season grass useful for suppressing weeds when successfully established at high plant population. Teff has very fine seed with 1.3 million seeds per pound so requires a low seeding rate of 5 to 8

pounds per acre. Teff requires a well prepared firm seed bed and a very shallow seeding depth to assure good germination. Plant after soils have warmed and first flush of weeds can be controlled by tillage. Teff produces a fine plant structure that doesn't leave soil clumpy for the next crop. Teff tolerates dry conditions once established better than buckwheat or sudangrass. It also requires less maintenance since buckwheat must be controlled when it matures and sudangrass requires mowing. Teff needs minimal mowing and generally does not produce seed, so volunteers are not an issue.

Sorghum-sudangrass (*Sorghum bicolor X S. sudanense*) is a cross between forage or grain sorghum and sudangrass often reaching 6 to 10 feet in height. It is a warm season annual grass that grows well in hot, dry conditions and produces a large amount of biomass useful for soil organic matter enhancement. To improve biomass production on nitrogen deficient sites apply at least 50 pounds per acre of nitrogen. It grows in well-drained to somewhat poorly drained soil but has low flood tolerance. Although optimum production is achieved when the pH is maintained between 6.0 and 6.5 it tolerates a pH 5.0 to 8.0. Sorghum-sudangrass is very effective at suppressing weeds and has been shown to have allelopathic properties. The roots of sorghum-sudangrass are good foragers for nutrients (especially nitrogen) and help control erosion. Sorghum-sudan grass has been reported to be highly effective in remediating compacted soils caused by farm equipment. It is recommended to mow when it reaches a height of 3 feet. If not mowed it can produce a large amount of residue which may become a management problem for subsequent seed bed preparation. Sudangrass growth is easier to manage because the stems are narrower and suppresses weeds better.

Buckwheat (*Fagopyrum esculentum*) is a very rapidly growing, broadleaf summer annual growing to a height of 2.5 feet in height with many lateral branches and many fibrous superficial roots. Buckwheat has higher tolerance to soil acidity and infertile soils than any other grain crop tolerating a pH of 4.5 to 7.5. It is best suited to light to medium textured, well-drained soils such as sandy loams, loams and silt loams; it does tolerate poorly drained soils but not flooding. Buckwheat will not break up hardpan and will not grow well on compacted soils. It can be sown from late May to early August in PHZ 5. It is typically sown as a smother crop at a rate of 50 pounds per acre drilled, or broadcast at 70 pounds per acre; then shallowly incorporated to 1 inch deep. It will grow making an excellent weed suppressing cover in 40 days, although weeds will grow in any gaps over 10 inches. Buckwheat flowers in 4 to 6 weeks and is very attractive to insects including bees. Buckwheat is an effective phosphorous scavenger. It is succulent, easy to incorporate, and decomposes rapidly. The main disadvantage to buckwheat is that it sets seed quickly and may, if not mowed or tilled, go to seed and become a weed problem in subsequent crops. For additional information on how to use buckwheat to bring idle land back into production refer to the Cornell University Buckwheat Guide.

Chapter 3

Purchasing Seed and Plants

Purchasing Seed

Certified seed as discussed later in this chapter should be your first choice for any seeding project. If certified seed is not available, try to obtain non-certified seed that may meet certification standards for purity, germination percent, weed seed, and noxious weed seed content. Inquire when choosing a particular seed lot to ensure that it meets the highest quality standards available from your supplier, since they frequently have more than one seed lot to choose from. A seed lot is seed of a particular crop harvested or gathered and processed in the same way at the same time. Successful plantings require the purchase of quality seed, otherwise the effort and expense of site preparation, planting, and management may be lost due to poor stand establishment. Certified seed may cost more per pound than common seed, but the assurance of quality is well worth the premium.

Introduced grasses and legumes can frequently be bought as mixes at local stores marketed as conservation mixes. It is not advised to purchase off-the-shelf mixes as these do not always contain the appropriate species or proportion to obtain the best results. When ordering individual species it is possible to get higher quality seed than what is in some off-the-shelf mixes. The purchase of native grass and forb (wildflower) seed requires more effort than the purchase of introduced cool season forage and turf seed. Native grass seed is produced by smaller companies and is sold at fewer stores. Most seed is bought in mid- to late winter and shipped to the purchaser. It is best to purchase seed at least two months before the expected planting date. In years with elevated seed demand or low seed yield, it may require earlier purchase to obtain the desired species, cultivars, or ecotypes or the best-quality seed lots.

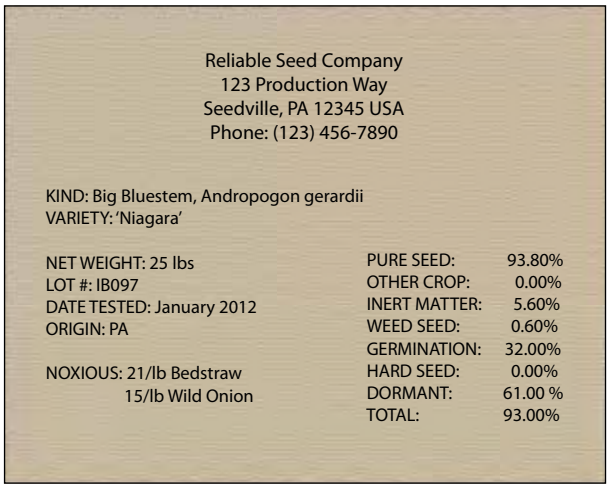
Reading and Understanding Seed Tags and Seed Tests

Samples of seed are submitted by state or certification officials, growers, seed conditioners, or seed dealers to obtain information that is required to be on the seed tag (Figure 3a). The seed lab performs a number of tests on a representative sample from each lot submitted. Seed tests are conducted under controlled conditions based on the "Rules for Testing Seeds" adopted by the Association of Official Seed Analysts, referred to in this document as the "official seed test".

There is some flexibility, based on the species being tested as to which types of pretreatments are used which include: stratification, scarification, growth regulators or other chemical methods. These methods result in the maximum potential germination from each seed lot under "laboratory conditions", which is used to compare performance between seed lots. These procedures are typically used with native warm season grasses, wildflowers and trees and shrubs. It is important to note that these tests improve germination in ways which are not used when direct seeding in actual "field conditions". This information is not always obvious from the seed tag so it may be warranted to contact your seed supplier for additional information regarding which procedures were followed to obtain the percent germination. If possible get a test without any pretreatment for comparison.

Purity Test

A purity test is conducted to determine the composition of the seed lot and to determine its degree of contamination by unwanted components. A purity test is conducted to separate the seed into the following components: pure seed, inert matter, other crop seed, and weed seed. These components must add up to 100 percent. For mixtures



Information Found on a Seed Tag:

1. Kind (species and common name);
2. Variety:
3. Lot number;
4. Origin;
5. Net weight;
6. Percent pure seed;
7. Percent germination:
8. Date of test;
9. Percent hard and/or dormant seed;
10. Total germination;
11. Percent inert matter;
12. Percent other crop seed;
13. Percent weed seeds;
14. Name of restricted noxious seed (number per pound of seed); and
15. Name and address of company responsible for analysis (seller).

Figure 3a. State and federal seed laws dictate the information found on the seed tag.

the percentage of each species is listed in order of predominance by descending order.

Pure seed is the marketed seed exclusive of inert matter, weed seeds, and all other seeds distinguishable from the kinds and varieties being considered for sale.

Inert matter includes dirt, plant parts, and certain types of damaged seeds. Most grass seed should contain no more than 15 percent inert matter. Even low percentages of inert matter containing pieces of stem or un-threshed seed clusters can block passage through a drill. Purity and inert matter of grass, forb, and shrub seed will vary by species, harvest and processing methods. Certain species are known to have more inert matter based on the morphology of the seed being harvested and cleaned. For agricultural seeds that are coated the following information is on the tag: (1) percentage by weight of pure seeds with coating material removed; (2) percentage by weight of coating material; and (3) percentage by weight of inert material exclusive of coating material.

Other Crop Seeds are species normally grown as a crop and unintentionally occur in the seed lot. If there is over 5 percent it is considered a planned part of the mix. The seed tag requires a percent by weight of the total of all other crop seeds. If the specific types of other crop seed are a concern, you may request a complete seed analysis report for the lot, which lists other crop species and the number of seeds per pound individually.

Weed Seeds found in the seed lot are reported as the combined total percentage by weight of common and restricted noxious weeds. The name and number of restricted noxious weed seeds per pound is also listed on the tag as required by law.

Prohibited, Restricted and Common Weed Seeds

During the purity test, the seed lot sample is examined for the presence of "restricted" and "prohibited" noxious weed seed and a list of those weeds is available from the seed analysis report. Each state has its own list of prohibited and restricted noxious weeds. All seed lots must meet the regulations of the state where it is sold. The Federal Seed Act and state laws do not allow "prohibited noxious weeds" in any seed lot, whereas "restricted noxious weeds" are allowed in a seed lot but are restricted to a limited number of seeds per pound. The name and number of seeds per pound of any restricted noxious weeds must be listed on the seed tag. Each state requires similar information, but the prohibited and restricted weed lists vary from state to state. By law, seed that comes from a state that has less restrictive weed lists must meet the more restrictive requirements of the receiving state. Contact the State Department of Agriculture or the crop improvement association in your state for specific information. A list of noxious weeds regulated by states is listed on the

USDA Agricultural Marketing Service web page, State Noxious Weed Seed.

Common weed seeds are those weeds that are not on the prohibited or restricted noxious weed lists and should not total more than 0.5 percent by weight. The major problem with common weeds is that it is hard to determine what they are because they are not listed on the tag. The only way to find out is from the seed analysis report. In general, the fewer weed seeds the better, as it is beneficial to avoid the introduction of any new weed species to a farm or ecologically sensitive area.

Seed Dormancy and Hard Seed

Seed dormancy is caused by physical, chemical or physiological mechanisms.

- Physical dormancy is due to an impervious seed coat preventing water uptake, seed imbibition and the onset of germination. Physical dormancy can be overcome by scarification, the rupturing of the seed coat by mechanical means. This type of dormancy is used to describe hard seed and is typical of legumes.
- Chemical dormancy is due to chemical inhibitors in the seed which prevent germination, this type of germination can be overcome by leaching.
- Physiological/morphological dormancy is due to seeds having underdeveloped embryos which prevents germination and can be broken via stratification or after-ripening in dry storage.

Seeds can have multiple mechanisms for dormancy. Dormant seeds may germinate at a later date and produce viable plants, they may germinate and succumb to competition, or they may never germinate at all.

The amount of dormant seed in a seed lot is important to know when purchasing seed. Dormant seed, which includes hard seed, refers to the portion of the seed sample that does not germinate during the official seed test and is still viable. Legumes are best known for hard seeds. Hard seeds are seeds that remain hard at the end of the official seed test period because they have not absorbed water due to an impermeable seed coat. Hard seeds look just as they did when planted with no increase in size since they have not imbibed water. After the official seed test those seeds which remained firm with no evidence of imbibition are considered hard seed. Those that have imbibed, did not germinate and squash when pressure is applied are considered non-viable.

Many grasses and native species are known to have varying types and amounts of dormancy other than hard seed. Seeds which have not germinated by the end of the official seed test and have imbibed water and are swollen in size need to be tested for viability. The tetrazolium chloride test (TZ test) in which seeds are stained with a dye is a method used to determine viable seed. Viable seed with live (respiring) tissues will stain a red color and are listed as dormant seed, while those seeds not stained are considered dead non-viable seed.

Germination Test

A germination test samples for percent germination which determines the capability of a seed lot to produce normal seedlings under specified standard laboratory procedures. For seed that does not germinate, additional procedures determine the percentage of dormant and/or hard seed as explained above. These percentages should be listed separately on the seed tag and lab report. If the seed is a legume then the dormant seed is considered hard seed and is listed separately as "hard seed "on the seed tag. If the seed is a grass or other non hard seed, then the seed that has not germinated after the official seed test is then given a tetrazolium chloride (TZ) viability test, and the percentage of seed exhibiting respiration is listed separately as "dormant seed" on the seed tag. Be aware that some approved standard germination tests allow for a pretreatment such as stratification which breaks seed dormancy and this may increase the germination rate reported in the germination percent compared to non-pretreated seed.

The minimum germination allowed to be sold is regulated by state agencies. Appendix 3a provides examples of minimum seed germination requirements for certified seed for some species. Typically for non certified seed to be sold it must meet two-thirds of the rate allowed for certified seed. The germination of most cool season introduced grass species is normally above 80 percent and should not be lower than 60 percent. Germination of some native grasses, forbs, and shrubs are typically lower, but can vary widely according to species.

Germination tends to decrease in all seed as it ages even under ideal seed storage conditions with some species and seed lots within species losing germination more rapidly than others. Cool season grasses tend to lose germination quicker than warm season grasses when both are stored in cold storage. The seed test date should be within 9 to18 months. This time interval will vary depending on state

laws for the particular seed types: turf, forage, legumes, flower, shrub, or tree seeds. Older seed can get retested, and if it still meets state minimum germination guidelines it can be sold with the new test date. When seed ages and germination rates drop, there is also a drop in seedling vigor, therefore it is always best to obtain seed lots with the highest germination rate possible.

Certified Seed

Certified seed is the progeny of seed that has been handled to maintain its genetic identity and has been approved by a certifying agency. There are four classes (generations) of certified seed used to track the seed as it is increased in quantity by seed producers to meet commercial demand. In order of genetic purity they are breeder, foundation, registered, and certified seed. The final generation designated "certified seed" is the only class sold to the consumer. Certified seed is designated by a blue tag. Certified seed meets established quality standards for germination, purity, and weed seeds. A cultivar/variety is formally released with distinctive traits documented as uniform and stable when evaluated over multiple locations and years. Since certified seed has a proven identity, the cultivars or ecotypes adapted to the region can be positively identified and purchased.

Several U.S. states have native plant certification programs that certify to "Pre-Variety Germplasm" using standards from the Association of Official Seed Certifying Agencies (AOSCA). The pre-varietal releases have three designations: source identified, selected, and tested. The "source identified" designation includes unevaluated germplasm identified only by species and geographic location of the wild growing parents. The geographic location is defined by the developer, and may be a small, restricted representation of the population, or may be collected from a large area in order to increase genetic diversity. Such a defined geographic area could potentially be synonymous with the boundaries of an ecotype which is a population of a species that differs genetically from other populations of the same species because local conditions have selected for certain unique physiological or morphological characteristics. The "selected" designation is germplasm showing promise of desirable traits, comprised of individuals selected from common site comparisons within the original population or from several populations. The specific selection criteria and the comparative data requirements become part of its record. The "tested" designation is germplasm for which progeny testing has proven desirable traits to be heritable. This progression may also serve as a route leading to formal native plant variety/cultivar release if eligibility requirements are satisfied. The seed from all of the pre-varietal classes and cultivars are usually increased over several generations to build up a supply to meet commercial demand. Additional information on native plant pre-varietal releases is available on line at the AOSCA Native Plant Connection website.

Pure Live Seed

Native grass seeding rates are frequently based on pure live seed (PLS), native forb recommendations may vary. PLS is the percentage by weight of the live seed in the seed lot. It subtracts all of the non-seed material such as plant parts, soil particles, weed, non-crop seeds and non-viable seed. Recommending seed based on PLS compensates for the inert material, non-viable seed and variability between seed lots. When seed is purchased based on PLS the buyer only pays for seed that is living and has the potential to produce a plant. The buyer does not pay for non-viable seed, seed of other crops, or inert material. For seed sold in bulk the cheapest seed is not always the most economical. By comparing the PLS between seed lots or mixes, you can clearly see which lots or mixes will produce the most potential seedlings after planting. The seeds produced from native plants frequently have higher amounts of inert material (plant parts) and nonviable seed in the final product. This leads to greater variability between seed lots in germination and purity. This variability is due to the difficulty in growing, harvesting, and cleaning many native grass seeds. The PLS content of a given lot can be calculated through information found on the seed tag, which contains data on the germination, dormant seed, and purity percentages of the bulk seed. The PLS is also used to adjust seeding rates to achieve the desired stand. Seeding rates based on a PLS basis, will insure that the same amount of viable seed per acre will be planted even though the quality of different seed lots and total amount of material (bulk) seeded per acre may vary considerably. The basic formula to calculate PLS is:

Percent PLS = (% Purity x % Live Seed) ÷ 100
Percent purity = 100% - (% of all material in the seed lot that is not the desired seed)
Percent live seed = % germinated + % dormant/hard seed, it does not count the non viable seed in the lot.

For example:

Percent purity = 90%
Percent live seed = 80%
Pure Live Seed (PLS) = (80 x 90) ÷100 = 72%

For calibrating drills or making your own mixes it is necessary to calculate the bulk or gross seed weight.

Bulk seed weight (lb/ac) = (PLS seed weight recommendation (lb/ac) ÷ (PLS% ÷ 100).

For example, if the recommendation for the above seed lot is 10 PLS lb/ac it will require planting 13.9 bulk lb/ac

10 ÷ (72 ÷ 100) = 13.9 bulk pounds.

If only 10 pounds of bulk seed is planted, it is 28 percent less than needed for an adequate stand. Seeding rates based on PLS insure the same amount of viable seed is planted per acre. Seeding rates are determined based on planting a predetermined number of live seeds per square foot to achieve a specific plant density. It is necessary to calibrate planters for the increase in bulk weight to achieve the desired stand. In the above example the drill needs to be calibrated to deliver 13.9 bulk pounds per acre. See Appendix 3b for more information on drill calibration.

The seed analysis of each seed lot may be used to compare the quality of the different lots to determine the best seed lot to purchase for both quality and cost. When ordering seed, request the percent purity and both the percent germination and percent dormant seed data for the seed you are buying, they may have more than one seed lot available to choose from. When purchasing seed, request seed lots with a high percent of germination and low dormancy. It is important to note that not all seed prices in catalogs are sold as PLS. Cool season grasses which typically have high purity, high germination and low dormancy are sold and recommended at a bulk rate. Wildflower seeds, on the other hand have great variability but are still typically priced as bulk. Specific instructions need to be given when recommending or purchasing wildflower seed and if ordering the seed PLS be aware that this can dramatically increase the cost of the seed compared to the catalog bulk price.

Mixing Seed

Although most grass seed is planted as a mixture, there are disadvantages to purchasing grass and forb seed pre-mixed, especially native seed. The cultivars and seed quality in a prepackaged mix may not be the best available. Moreover, unwanted species may be included or desirable species may be excluded. Plans for the planting may change, requiring changes to the seed mix. Seed may need to be mixed in various ways due to seed size, shape, and texture. Depending upon the type of seeding equipment the seed may need to go into separate hoppers. Additional information describing the use of seed drills and other seeding equipment is given in Chapter 4. Seed of different species often settle differently in the bag affecting proportion and distribution of seed in the planting.

Purchasing Introduced Grass and Legume Seed

For information on varieties refer to the National Turfgrass Evaluation Program website. Some land grant colleges have data on varietal comparisons of grasses and legumes used for forage production; many of these forage grasses and legumes can be used for critical area seedings and conservation cover. Descriptions of some older cultivars still being marketed can be found in "Grass Varieties in the United States," USDA Agriculture Handbook 170, Alderson and Sharp, 1994.

It is recommended that each species in a mix be purchased as a separate lot of certified seed. This allows smaller seeds to be placed into separate hoppers. For example, redtop seed (Figure 3b) is much smaller than perennial ryegrass and most other grasses and seeded in small quantities. Redtop could be placed in the legume/small seed box with other small seeded species. This would prevent the separation which would happen if small seeds are placed together in the grass seed hopper with a mix of larger seeded grasses. Buying legume seeds separately allows for the proper inoculation of legume seed prior to mixing. Mixing large amounts of seed can be a challenging, but the advantages outweigh the disadvantages. Some seed companies will custom mix orders and sort seed of similar sizes to take advantage of the flexibility of seeding equipment. If seed is bought premixed, it should be remixed prior to filling the hopper.

Conservation mixes available at garden centers and other outlets sometimes contain large percentages of

Figure 3b. The difference in size between redtop (left) and perennial ryegrass (right) is an example of how seed characteristics can effect uniform handling and distribution of seed.

annual ryegrass and perennial ryegrass and should be avoided where erosion control is the primary concern. If mixes are used, avoid mixes with annual ryegrass greater than 5 percent or perennial ryegrass greater than 15 percent. Always check the germination rate for all of the species and adjust accordingly. Although these species establish quickly they can interfere with the slower germinating but longer lived species such as fescues and birdsfoot trefoil. Introduced grass and legume seed due to their typically high germination rate is usually marketed as bulk seed and not PLS. In some cases legume seed comes with a clay or lime coating which can significantly reduce the PLS due to the coating material and for some applications the seeding rate should be increased based on the PLS calculation.

Purchasing Native Grass and Wildflower Seed

When planting native grass and wildflowers (forbs), individual lots of seed must be purchased separately and mixed at the time of planting. This is especially true when a native seed drill will be utilized where seeds of different sizes and textures will be placed in specialized hoppers. This allows for the selection of the best seed lots available and/or for the purchase of seed from multiple sources. Smooth seeded species (Figure 3c) include: switchgrass, deertongue, sand lovegrass, eastern gamagrass, purpletop, and coastal panicgrass. They may be planted with most conventional agricultural drills or spinner-type broadcast seeders. Eastern gamagrass needs to be planted deeper (1.5 inches) than the other species and is sometimes planted with a corn planter in a

Figure 3c. Switchgrass seed is smooth and readily flows through conventional seeders.

separate operation. Chaffy seeded species with awns (Figure 3d) include: bluestems, indiangrass, sideoats grama, and wildryes. They require a native grass drill with a specialized hopper to be accurately and uniformly planted. Additional information about developing seed mixes and seeding native grass and forbs is covered in Chapter 4. Chaffy grass seed can be de-bearded to remove the chaff to assist in their use in conventional drills, although flowability problems may still exist. This also increases the flow rate in the native seed hopper making calibration difficult especially for low seeding rates. Some native cool season grass seed such as the *Agrostis* spp. are so small (> 5 million seeds per pound) that very small amounts are needed in a mix. Small seeded species require special care to ensure even distribution of the seed.

Figure 3d. Big bluestem seed has awns that need specialized seed hoppers to facilitate flow.

Native forb seed production is more specialized than the production of grass seed. There are cultivars and ecotypes of some forb species being grown under seed certification systems but most are not. In some cases, native harvested material is sold directly and the variability in seed quality between seed lots increases greatly. Usually the native harvested seed is increased a generation or two from native harvests to scale up production. In either case, the adaptation and repeatability of performance is not always known. For some species there are also cultivars produced specifically for the horticulture trade and are not intended for native plantings. Native forb seeds vary greatly in size and shape. It is recommended that these seeds be purchased in separate lots and combined into groups based on size and shape. This is especially important when forbs are the primary component and a native grass drill with a specialized hopper, is being used. Another method, especially useful when planting small amounts of forb seed per acre, is to weigh the mix in small increments and periodically mix with the grass seed in the planter to facilitate uniform distribution. If bought in a mix the entire mix should be agitated well prior to redistributing into hoppers or divided into smaller units. Be cognizant as to how the seed price is listed in the catalog, most wildflower seed is listed in bulk not PLS. If you order in PLS get a cost estimate since you will get more bulk seed and the price for your order could increase significantly.

Purchasing Plants

Nursery stock may be shipped around the country as plants progress from the seed source, to the seedling producer, to the containerized grower. The demand for native planting stock, originating from defined geographic regions is increasing. If native ecotypes are a priority, make sure the supplier uses seed and seedlings from identified sources. State tree nurseries and other commercial nurseries may have native seedlings available that are grown exclusively from seed and cuttings originating in that state. Plants used should be adapted to your plant hardiness zone. If the origin of the parent material is unknown, you cannot determine its adaptiveness. Trees and shrubs are susceptible to invasive insects and diseases; avoid planting species which are currently or potentially vulnerable to these pests. Not all species listed in Appendix 2i - l, are commercially available, check with suppliers before finalizing a planting plan.

For nursery stock specifications use the American Standard for Nursery Stock available on the American Landscape and Nursery Association (ANLA) website. The purpose for the American Standard for Nursery Stock is to provide buyers and sellers of nursery stock with a common terminology in order to facilitate transactions involving nursery stock. For instance, the standards establish common techniques for: (1) measuring plants; (2) specifying and stating the size of plants; (3) determining the proper relationship between height and caliper, or height and width; and (4) determining whether a root ball or container is large enough for a particular size plant.

Herbaceous Plant Material

Vegetative materials are available as bare root seedlings dug from a nursery, vegetative propagules, rooted cuttings, seeded plugs, tublings, or larger containerized plants. Dormant propagules such as rhizomes, divisions, or bare root seedlings should be kept in a cooler or a cool, moist environment prior to planting. They should be planted as soon as possible and must be kept from drying out during the planting process.

Plugs and rooted cuttings are available in different cell sizes and shapes with flats up to 500 cells. Seventy-twos (flats with 72 cells) contain very small plants with small soil volumes in cells that are 1.5 x 1.5 by 2.5 inches deep. These are grown so that they can be transplanted by nurseries into larger containers. Flats with 32 cells that contain larger plants with cell soil volumes that are 2.25 x 2.25 by 3 or 5 inches deep are also available (Figures 4k and 4l). Small plugs are more vulnerable to drying out and to frost heaving than larger plugs, but can be used if planted at the optimum time, mulched, and watered as needed. Plugs greater than 5 inches in depth are more reliable for direct planting on landscape projects. Tublings are another type of container with a depth of 8 inches or greater. They are used to grow plants with deeper root systems and can be handled individually. Larger container sizes are also available. The larger the container and plant the higher the survival rate, quicker canopy cover and time to flower. However, larger containers increase the cost and labor to establish. For a list of native plant nurseries by state go to the Plant Native website.

Tree and Shrub Planting Stock

Field grown bare root seedlings and rooted cuttings are grown in nursery beds. They may be sold after one year or may be dug and replanted in a nursery before sale. This type of stock is the most economical, but requires the most care in handling and planting. Containerized plants extend the planting season when there is adequate rainfall or irrigation. In addition, the roots of containerized stock are less likely to become dry during the planting operation. Containerized plants are also less likely than bare root seedlings to form J-roots. J-roots result when improper planting bend roots in the planting hole back towards the soil surface which may not develop properly, causing plant stress. For some conservation plantings such as windbreaks and screens large containerized size trees may have some advantages when the numbers of plants needed are not too great. Trees greater than 5 feet raise the terminal buds past deer browse pressure but are still subject to damage by buck rubbing and may still need protection. The cost and handling of this size material may not be practical for large acreage. Further planting instructions are covered in Chapter 4.

Bare root stock labeled 1-0 was grown in the original propagation bed for one year before sale, 2-0 stock was grown for 2 years in the originating bed. Stock labeled 2-1 stock was grown for two years in the original propagation bed, transplanted to a nursery bed for one year then sold. Species are held and transplanted for reasons such as, slow initial growth or to produce stronger root systems. Bare root stock must be planted in early spring before growth begins. Roots are typically cut during field digging, predisposing bare root plants to transplanting shock if planted after dormancy is broken. Bare root stock is normally the least expensive, but when handled improperly, can have the highest mortality. When handling or transporting bare root stock, keep the roots moist and cool, protected from sun and wind exposure at all times. Some nurseries specialize in larger bare root material.

Container grown stock has been growing in a container throughout its production cycle and did not originate from field grown material. The roots of these plants are not disturbed at the time of planting so container grown plants suffer little transplant shock. Container grown plants may be planted at any time during the growing season provided there is adequate rainfall or supplemental watering. Container grown nursery stock should have a well-established root system reaching the sides of the container to maintain a firm ball when the container is removed (Figure 3e). Root-bound plant material should be avoided. Do not break up the root ball, but cut any roots circling the root ball prior to planting. Failure to interrupt the roots from growing in circles will frequently cause the plant to die after a few years even if it survives the transplanting. Container grown stock can be upgraded to larger pots and grown in the container for more growing seasons. Nurseries often use techniques to induce root pruning in container grown plants to stimulate secondary root branching and to create fibrous non-circling root systems. Tublings (Figure 3e) are seeded directly into conical tubes grown in the greenhouse and moved outside to a cold frame or lath house for hardening-

Figure 3e. Container grown stock and tubling with well-established root systems that hold the media together when removed from the pot.

off before use. They are about the same size as bare root seedlings. For trees and shrubs, purchase tublings that are at least 8 to 9 inches deep, 2.5 to 3.5 inches in diameter and with a volume of at least 50 cubic inches.

Containerized stock is grown in a nursery bed and transplanted to a container. Containerized trees and shrubs are dug from the nursery in the spring or fall as bare root stock, placed in a container of growing medium, and sold in the container. If containerized in early spring, most plants will be sufficiently re-established by summer or fall. It is imperative that the bare root stock's root system has been fully re-established and able to hold the media together when removed from the container. Follow procedures discussed above for root-bound stock.

Balled and burlapped (B&B) plants have gone through any of the steps above before being grown to a large size in the field. They are dug with a firm ball of soil around the roots. The soil ball is held securely in place with burlap, twine, or a wire basket. The stem should not wobble in the soil ball. Always lift B & B plants from beneath the ball, never by the stem. Due to the weight of the soil ball, with trees larger than 1- inch caliper weighing over 160 pounds, B & B trees can be difficult to transport and plant without special equipment. Large plants may be dug and moved by a hydraulic tree spade to a previously dug (by the same tree spade) planting spot or they may be placed in a wire basket lined with burlap. Prior to planting with a tree spade, call appropriate authorities to locate underground utilities. Matching soils from the digging site to the planting site may be important. It is best when fall planting B & B trees to use trees that were dug in the spring and appropriately held over during the growing season, then to dig in the fall just prior to transplanting. Trees which have been root-pruned every few years in the nursery transplant much better. The size of the root ball is critical and species or "type" dependent. For example shade trees with 0.5, 1.0, 1.5 and 2.0 inch caliper size (6 inches above ground) requires a root ball diameter of 12, 16, 20 and 24 inches respectively, Specific root ball diameter recommendations for different tree and shrub types can be found on the ANLA American Standard for Nursery Stock website. Although B & B stock is often the most expensive it is the only option for the largest tree sizes. When handled and planted properly, B & B stock is as reliable as container grown material.

Purchasing Woody Plant Materials for Soil Bioengineering

Soil bioengineering and biotechnical slope protection techniques as discussed in Chapter 4, place plant

materials into conditions where there is mechanical and environmental stress. This is evident in stream bank and lakeshore applications. Woody plant materials for these projects may be obtained by harvesting stems from native stands or from nursery grown material. Nursery-grown material is vigorous, consistent, and easier to handle and plant. Trials and application have shown nursery-grown material to have a significant performance edge. Willow and dogwood cultivars and ecotypes can be obtained from nurseries. 'Streamco' purple osier willow has proven to be very effective for soil bioengineering. It is a non-native male clone so plants do not spread by seed. There is concern for its non-native status so consider using only in high-priority (urban or suburban) areas for special applications such as with live crib-walls, and away from areas in which purple osier willow has not already been introduced. Willow and dogwood nursery material is often sold per stem, by age and dimension so that the exact material needed can be obtained. There is increased interest in native soil bioengineering woody plant material and some nurseries are now increasing production of those species. Native willows were collected from multiple locations in the Northeast and are being evaluated at the USDA-NRCS Big Flats Plant Material Center to select ecotypes which may perform better for soil bioengineering and may have improved insect and disease resistance. These willow ecotypes will eventually be sold by commercial nurseries.

When harvesting soil bioengineering material from native stands follow some of the precautions outlined in Chapter 4 in the section discussing, "Factors to consider when moving plants from local donor sites." Native stands of willow and other soil bioengineering species may have a history of insect and disease infestation which can stress the plants. Extremely dry years or long periods of drought may also cause plant stress. This stress means that the stem cuttings may not have peak energy reserves. Low energy reserves translate into lower establishment success.

If the priority is to avoid non-native willows, care needs to be taken to identify the willows in the areas that will be cut a year prior to harvest. Purple osier willow (Salix purpurea) is easy to identify and is distinct from all other willows in its sub-opposite to opposite leaf arrangement and long whip-like growth habit (Figure 3f). There are other non native willows which should be avoided such as large gray willow (*S. cinerea*), silky or basket willow (*S. viminalis*), rusty willow (*S. atrocinerea*), all weeping willows, and others. Information on identifying willows which are growing in the Northeast can be found on the SUNY-Environmental Science and Forestry, Integrated Vegetation Management Research and Development website.

Diversity of plant species in willow and dogwood cultivar plantings can be achieved by adding native species and ecotypes into the planting. Local native plant materials such as willow, dogwood, or elderberry when available, can be mixed with the cultivar or selected materials. Upland willows including flowering dogwood (*Cornus florida*) and tree willows such as black willow (*Salix nigra*) are not used for soil bioengineering but can be used where appropriate above the stream bank. Additional species that do not root as well as willow can be planted as bare root or containerized stock. Both approaches provide the planting site with diversity and native, long-lived species. Refer to Appendix 3c for a list of species in the Northeast suitable for soil bioengineering and some of their characteristics useful when planning soil bioengineering projects. Further information on soil bioengineering techniques is covered in Chapter 4 and the NRCS engineering field handbook Chapters 16 and 18.

Figure 3f. Purple osier willow exhibiting opposite to sub-opposite leaf arrangement useful for plant identification.

Chapter 4

Techniques for Seeding and Planting

Planning

There are many items to consider when planning a seeding, especially in erosion-prone areas and in areas with construction activities. Assessment of site conditions should include topography, soils, compaction, hydrology, high water flows, and ability to irrigate.

- Be aware of the surrounding land uses and avoid disturbing adjacent areas.
- Assess the existing vegetation on the site and in adjacent areas, including noxious or invasive weeds or threatened and endangered plants.
- Evaluate the amount of shade.
- Evaluate, protect and stockpile topsoil whenever possible.
- Plan for any needed permanent or temporary auxiliary practices to ensure safe disposal of runoff water, slope stabilization, compaction remediation, erosion control, and drainage and sedimentation abatement.

Plan practices such as waterways, diversions, grade stabilization structures, retaining walls, and subsurface drains to safely conduct surface water to storm drains or suitable watercourses. In areas having a high water table or having seepage, surface or subsurface drainage should be provided to intercept water that would affect slope stability, building foundations, or create undesirable wetness. The grading plan and practice installation should be based upon topographic surveys and investigations following appropriate engineering standards and specifications. Call appropriate authorities to locate underground utilities prior to excavating. Also, be sure to coordinate final construction activities with the recommended planting windows for the species being planted. If this is not possible, protect the site with temporary seeding and mulching until seeding or planting at the proper time of year.

Landowners should be cautioned about wetland alteration, referencing Section 404 of the Clean Water Act (33 U.S.C. 1344) and the Wetland Conservation Provisions of the 1985 Food Security Act as amended (Federal Regulations CFR Part 12). Do not conduct activities that will alter the hydrology of a wetland or stream. Protect adjoining properties from sedimentation associated with excavation and filling operations, follow all state and local erosion and sediment laws, and obtain all required permits.

Site Preparation for Critical Area Plantings

The objective for site and seedbed preparation is to create a condition where seed is planted and seedlings emerge in a favorable microenvironment. Proper site preparation allows for the maintenance required to support protective vegetative cover and future land use. When construction starts, strip and stockpile topsoil from areas to be disturbed. Remove and dispose of logs, brush, rocks, stumps, and vegetative material that may interfere with grading or affect the planned stability of fill areas. Where practical, grade to permit use of conventional equipment for seedbed preparation, seeding, mulch application, and maintenance. When using a drill, cultipacker-type seeder or a tree planter, remove rocks over 3 inches in diameter. For parks and lawn areas, remove stones down to 1 to 2 inches. Broadcast seeding or hydroseeding may not be hindered by obstructions but debris and stones will hamper future maintenance.

Where compaction is a problem, fracture compacted layers 9 to 12 inches deep to allow for effective plant performance. Soil bulk densities of 1.6 to 2.0 grams/cm^3 are the upper limit for most plant roots. There is a difference in root growth at the same bulk density on different soil textures. Refer to Table 4a to determine ideal bulk densities for the soil texture of the site.

Sites that have been bare for a significant period of time frequently require regrading due to erosion. However, regrading of soil material may bring undesirable compounds to the surface. Where leaching of salt or other contaminants may have improved the soil surface layer, keep grading to a minimum. If the existing soil is unsuitable for plant growth, a cover of topsoil may be needed.

Weed Control for Conservation Plantings

All herbicide usage must follow the manufacturer's labeling and state pesticide regulations for the state in which the product will be applied. Recommendations for the treatment, including specific herbicides, rates, and timing, should be from published sources of information such as from state land grant colleges, which are based on the current manufacturer's labeling and annual reviews. Where published recommendations are not available and for additional information relating to herbicide treatment methods, seek advice from the manufacturer and a consultant with the appropriate state pesticide applicator certification.

Weed control of existing perennial cover and invasive weeds is important where the objective is to change species composition for wildlife habitat improvement or other conservation objectives. This is easier on sites where tractors can easily maneuver. It is important to realize that in many cases there is a seed bank of both annual and perennial weeds which will emerge with the planting and follow-up weed control may be necessary. Start weed control at least a year in advance using a non-selective, foliar applied, systemic herbicide. This may take more than one application. Another weed control option is planting row crops in advance of conservation plantings using registered herbicides for the crop. Organic weed control methods such as repeated tillage and smother crops can also be used. Depleting the seed bank using mechanical or herbicidal methods prior to seeding is especially helpful in wildflower and warm season grass plantings. During seedling establishment, if annual weeds are present, mow at a height just above the developing seedlings. Typically, mowing occurs throughout the season starting approximately 30 days after the seedlings emerge. Continue mowing periodically to allow for sunlight to reach the seedlings and to prevent weed biomass from accumulating to the point where clippings will smother the new seeding. Do not mow when excessive surface soil moisture will negatively impact seedlings due to wheel traffic. Seedings of grasses with no broadleaf forbs or legumes may use broadleaf foliar herbicides. Usually, grass seedlings need to be at the 4- to 5-leaf stage prior to a broadleaf contact herbicide application to avoid herbicide injury. All herbicide recommendations should be made by a consultant with appropriate state pesticide applicator certification following all manufacturer's labeling.

Table 4a. General Relationship of Soil Bulk Density to Root Growth Based on Soil Texture[1]

Soil Texture	Ideal Bulk Densities	Bulk Densities that May Affect Root Growth	Bulk Densities that Restrict Root Growth
	g/cm3	*g/cm3*	*g/cm3*
Sands, loamy sands	<1.60	1.69	>1.80
Sandy loam, loams	<1.40	1.63	>1.80
Sandy clay loams, loams, clay loams	<1.40	1.60	>1.75
Silts, silt loams	<1.30	1.60	>1.75
Silt loams, silty clay loams	<1.40	1.55	>1.65
Sandy clays, silty clays, some clay loams (35-45% clay)	<1.10	1.49	>1.58
Clays (>45% clay)	<1.10	1.39	>1.47

[1] Pierce et al., 1983. Productivity of soils: Assessing long-term changes due to erosion. J. Soil and Water Conservation 38:39-44.

Carryover from recent herbicide treatments used on previous crops can pose a threat to new plantings. Know what, if any, herbicides were applied and when. The persistence of herbicides is affected by factors such as soil pH, organic matter, texture moisture, and chemical half-life. To assess risk before planting, read the herbicide label or contact the manufacturer or a consultant. If time allows, and herbicide carryover is a concern, conduct a bioassay by potting some of the soil and observing the impact on the seed mix. Sometimes other species such as oats or cucumbers are used depending on their known susceptibility to the suspected carryover herbicides. Evaluate the roots as well as the top growth.

Soil Sampling

The application of fertilizer without a soil test may result in inefficient quantities of nutrients for plant establishment or could result in over-application of nutrients leading to nutrient runoff and degradation of water quality. State nutrient management regulations may require soil sampling to determine fertility levels prior to fertilizing to prevent unnecessary phosphorus applications. Some states have regulations requiring fertilizer application setbacks from streams and other water bodies.

Soil should be sampled and tested for nutrient status, pH, percent fines, if very sandy or gravelly, and bulk density if compacted. Soil test reports supply recommendations for lime, macronutrients (N, P, and K) and some micronutrients. For an accurate planting recommendation, the soil test should include soil name, crop history, manure application history, species in the mix, soil association, soil texture, and depth of incorporation. On disturbed sites, soil material may vary greatly due to mixing and filling, making individual soil sampling difficult. In this instance, specialized soil sampling and testing procedures will be needed. Consult with a soils engineer or agronomist about the sampling procedure. Soil samples for nutrient and pH analysis are taken from the entire depth in which the soil amendments will be incorporated, usually the top 4 to 8 inches. Avoid including grass and other plant residues in the sample. For conservation plantings take soil samples from representative areas based on soil series, topography, or past management. There may be more than one management area within the planting so these areas will need to be sampled and treated separately. Approximately two to three random subsamples per acre should be taken and bulked for each management unit. The composite sample should be mixed well, air dried, and a pint size subsample submitted for analysis. Consult the soil testing lab or your Cooperative Extension office for more complete soil sampling procedures. Sample before construction is complete, as it can take some time for results to be reported. When borrowed material or topsoil will become the surface layer of the site, this material should also be sampled. Use a soil testing laboratory that has been accredited by the North American Proficiency Testing Program.

Most critical areas receive soil amendments such as lime, fertilizer, and/or organic amendments (e.g. compost) only once as they are being planted. Since follow-up applications of lime or fertilizer are unlikely, the initial fertility inputs should meet the fertility requirements of the plant's establishment period. For high-priority sites with public safety concerns such as dams, soil samples should be periodically taken especially when onsite reviews indicate that the protective cover is thinning, species composition is changing to less desirable cover, or other concerns that may be noted. Submit soil samples to a certified lab and apply soil amendments based on the results of the soil test.

Soil pH and Lime

Good soil conditions fall in the pH range of 6.0 to 7.0. Plant problems begin when the pH is below 5.5 and above 7.5. Additional information on soil pH was covered in Chapter 1. Soil acidity is damaging to the growth of legumes and also adversely effects rhizobial nodulation and N-fixation. This damage is most acute during the seedling establishment period. The recommended soil pH value for grasses is 5.8 to 6.2. The recommended soil pH values for clover and birdsfoot trefoil are 5.8 to 6.2 and 6.3 to 6.5 respectively. Cool season grasses can tolerate pH values down to 5.2, and some warm season grasses can tolerate pH values of 4.5 or below. Refer to Appendices 2c-2l, for specific plant characteristics of the species covered in this guide. If the pH is really low, around 4.5, it may be more economical to choose species such as fine fescues and warm season grasses that can tolerate lower pH.

The best pH range for phosphorus uptake in plants is 6.0 to 7.0. At lower pH ranges, heavy metals such as aluminum and manganese can cause toxicity affecting legumes and cool season grasses first. At a pH above 6.5, iron and manganese deficiency can be a problem for some trees and shrub species.

Lime requires time to react in the soil. The lower the pH the more lime needed and the more time it takes for pH to reach the desired level. This will depend on soil texture, mineral composition and organic matter which affects cation exchange capacity (CEC) of the soil. Soils high in clay and organic matter typically have a high CEC and require more lime. Sandy soils have a low CEC, and need less lime to increase the pH, but require more frequent lime applications to maintain the desired level.

Liming to optimum pH increases the availability of essential nutrients, supplies calcium (Ca) and magnesium (Mg), improves soil conditions for microorganisms, and improves soil structure. Apply lime to achieve the specific requirements for the most pH sensitive species in the mix. If Mg is low use a high Mg (dolomitic) lime; the use of magnesium sulfate (epsom salts) will add Mg but is not a liming material.

Lime recommendations in some states are based on 100 percent effective neutralizing value (ENV) of the liming material and in others by calcium carbonate equivalents (CCE). CCE is the amount of soil acidity a liming material can neutralize compared to pure calcium carbonate. Calcitic limestone is pure calcium carbonate ($CaCO_3$) and has a 100 percent CCE and is the standard which all other liming materials are compared. The CCE is given as a percentage and is in direct proportion to calcitic limestone. A 109-percent-CCE limestone such as a dolomitic limestone would require 100 ÷ 109 = 91.7% as much liming material as calcium carbonate to achieve the same neutralizing ability. The CCE indicates only the equivalent neutralizing value of an agricultural lime material, it is not the calcium carbonate content of the material. The CCE is based on the chemical analysis of the liming material. Examples of liming material are: $CaCO_3$, CaO, $CaMg(CO_3)_2$, and $Ca(OH)_2$; these materials vary in their degree of liming activity in relation to calcium carbonate ($CaCO_3$) and most have higher neutralizing capability. Calcitic limestone ($CaCO_3$) 100 percent and dolomitic limestone ($CaMg(CO_3)_2$) 109 percent, are the materials most used for agricultural liming. The other materials are burned lime (CaO) and hydrated lime ($Ca(OH)_2$ with CCE's of 179 and 136 respectively, these have higher neutralizing value and are in a powdered form which react within the year but are more expensive and are more caustic to use. The CCE based lime recommendations do not take into account particle size.

The effective neutralizing value (ENV) is calculated by multiplying the CCE percent by a particle size distribution factor which estimates how much lime material will be available to change the soil pH within a year. Particle size distribution information used to calculate the particle size factor as well as the CEC and ENV of the material is provided on the liming label. More information on how to calculate the particle size factor, ENV and CEC can be found on the Cornell University, Nutrient Management Spear Program, Agronomy Fact Sheet web page and in the "Lime Guidelines for Field Crops in New York" fact sheet.

When liming recommendations are made in ENV, the actual application rate of a specific liming material needs to be corrected for the ENV of the material. To calculate the actual application rate of a particular lime divide the recommended ENV rate in tons/ac by the ENV % of that particular lime and then multiply by 100. For example, if the ENV is 78 percent and the recommendation is for 3 tons/ac ENV then 3 ÷ 78 x 100 = 3.85 tons/ac of this liming material needs to be applied to equal 3 tons/ac ENV.

The particle size (fineness) determines the speed of the reaction of the liming material, the higher percentage of finer ground material, the more surface area coming into contact with the soil, and the faster it will react. Fineness or particle size is the percent that passes through sieves of specified mesh sizes, the higher the mesh number the lime material passes through, the finer the material. The particle size factor used for ENV for agricultural limestone is based on the amount that can pass through a 100-mesh sieve and not through a 20-mesh sieve. One hundred percent of lime particles passing through a 100-mesh sieve will react within the first year, while only 60 percent of the liming materials passing through a 20-mesh sieve (but not through the 100) will react within the same time frame. Very coarse material that does not pass through the 20-mesh sieve is not expected to react within a year and may take up to 3 years or longer.

Some States take the approach that it is more economical to apply lime with a fineness that will react within a 3 year period and consider a material with at least 95 percent passing through a 20-mesh sieve, 60 percent passing through a 60-mesh sieve, and 50 percent passing through a 100-mesh sieve as generally adequate. In these states the use of CCE is used to compare the liming material.

States have liming laws which require different information on their liming labels including

manufacturer's identifying information, the following is an example of some information provided when purchasing liming material useful in determining lime quality: (1) the type of liming material; (2) the effective neutralizing value; (3) the quantity of a given liming material required to equal 100 percent ENV; (4) the chemical analysis including the percentages of Ca and Mg; (5) the particle size distribution expressed as minimum percentages by weight passing through the US standard 20-and 100-mesh sieves and; (6) moisture content. In some states the addition of CCE and 60 mesh-sieve analysis is required.

Lime requirements and recommendations also need to be adjusted depending on tillage depth, and this depth should be provided on the form when the soil sample is sent in for analysis. Lime rates must be increased or decreased with tillage depths for the same desired increase in pH. The deeper tillage results in mixing of a larger amount of soil with the liming material therefore needing more lime, while shallower tillage will need less lime.

Pelletized limestone is made by granulating finely ground agricultural lime and binding the material together to form a pellet. The price per ton of pelletized lime is considerably higher than bulk agricultural lime but is more convenient to handle and can be broadcast with conventional fertilizer equipment. The recommended rates and the effect on soil pH of pelletized lime is calculated the same as agricultural lime based on the chemical analysis and the fineness of grind and is represented as ENV. Pelletized lime is usually ground finer than agricultural lime but it has been found that the rate of reaction is about the same as agricultural lime due to the time it takes the binding agent to break down and the fact that the pellets are not as uniformly distributed as bulk powdered lime.

Lime application rates of 3 tons per acre or more need to be incorporated. If lime recommendations are greater than 4 tons per acre start applying lime a year before seeding. Mix the initial 4 tons into the profile to a depth of 6 to 8 inches and the remaining lime into the top 3 to 4 inches. If hydroseeding it is preferred to spread lime prior to seeding using other equipment, not in the hydroseeder. There are products which are used in hydroseeders which cause less harm to agitation pumps than agricultural lime, but will not supply enough lime to sufficiently amend the soil profile and may be of limited use.

When a soil test is not available, apply lime according to the rates specified in Table 4b.

For no-till applications, such as wildlife conservation plantings, requiring more than 3 tons/ac lime, it is best applied in as fine a grade as possible at least a year in advance. Surface applied lime moves through the soil profile at 1/4 to 1/2 inch per year.

For additional information on how to interpret soil tests for lime use land grant college recommendations. Cornell University, Nutrient Management Spear Program, has information on their Agronomy Fact Sheet web page.

Sometimes there is a need to lower the pH due to: (1) accidental over application of lime; (2) requirement of a specific species; (3) calcareous soil type; or (4) an industrial waste site. Adjusting the pH from an over-application of lime or adjusting a non-calcareous soil for a specific plant is easiest to remedy using aluminum sulfate or elemental sulfur. Follow recommendations from a soil test and Cooperative Extension. In many

Table 4b. General Liming Recommendations Based on Soil Type

Soil Texture	Limestone Application Rate[1]	
	Tons/Acre	*Pounds/ 1000 ft²*
Clay, clay loam, and highly organic soil	3.5	157.5
Loam, silt loam	2.5	112.5
Sandy loam, loamy sand	1	45

[1]Based on raising the pH to 6.2 from a 5.5 soil test kit reading

Source: Cornell Guide for Integrated Field Crop Management, 2012.

cases, the pH can be lowered simply by using fertilizers containing ammonium-N. It is usually not practical to lower the pH of a calcareous soil. When sulfur is added to a calcareous soil, sulfuric acid is formed and some of the CaCO3 dissolves, but as long as CaCO3 remains in the soil and is a part of the parent material, the pH cannot be permanently lowered. Temporary decreases of pH in highly buffered high lime soils treated with sulfur are possible. However, the detrimental effects of excess sulfur on the plants usually outweigh any benefit from the slight pH decrease. For industrial waste sites consider bringing in fill and topsoil to cover the site and amending that soil for plant growth.

Fertilizer

The primary nutrients needed for plant growth are nitrogen, phosphorus, and potassium. Phosphate (P_2O_5) and potash (K_2O), which are the formulations used in fertilizers, should be applied in quantities sufficient to support vegetative growth during the establishment period after which maintenance applications should be applied as needed. These nutrients are important to the stress tolerance of plants, root growth, and photosynthesis. They are sometimes banded near the seed for crop production, but for conservation plantings they may be incorporated into the soil and will generally remain stable.

Nitrogen is more mobile in soils and the environment than phosphorus and potassium. Nitrogen, especially in the nitrate form, can be lost from soils by leaching during periods of high rainfall, reducing its availability to plants and sometimes finding its way into streams. Under wet anaerobic conditions, nitrogen can be lost by denitrification and converted to gaseous forms of nitrogen (N_2) or nitrous oxide (N_2O). For revegetation projects, a low rate of nitrogen fertilizer is recommended (50 pounds per acre of N or less) in the establishment year. Generally, ammonium forms of nitrogen are slower to be lost than nitrate or urea formulations. Urea formulations are the least expensive form of granular nitrogen fertilizer, but they can easily volatilize when broadcast on the surface. For this reason, urea formulations applied to the soil surface should be incorporated to a minimum depth of 3 inches, timed prior to a 0.5 inch rainfall event or treated with urease inhibitors. Soil that has had 2 tons or more of limestone per acre surface applied within the past three months should not have urea-based fertilizers applied unless they can be incorporated into the soil. This is due to the fact that the Ca in the lime can react with the urea fertilizer and release ammonia gas resulting in nitrogen losses. To avoid nitrogen losses over winter, avoid applying nitrogen late in the season, and never at the end of the growing season. When seeding late in the season consider applying nitrogen the following spring. Warm season grasses do not need to be fertilized with nitrogen during the establishment year, due to their slow seedling growth and the negative impact of fertilizer stimulating weed growth increasing weed competition.

Newly established plantings use less nitrogen earlier in the growing season than they will later. Slow-release nitrogen fertilizers, sometimes referred to as water insoluble nitrogen (WIN), can be valuable when this is a consideration. These slow-release nitrogen fertilizers are created by several methods: (1) treatment with nitrification or urease inhibitors to slow the mineralization conversion process of urea and ammonium to nitrate; (2) coated with low water soluble compounds that undergo chemical or microbial decomposition allowing for a slower release of nitrogen; or (3) Coated with specialized polymers with temperature sensitive differential permeability for a more controlled release over a longer period of time. These sources are more expensive than conventional fertilizers but can be valuable in areas that need water quality protection or to maintain a slow release of nutrients in coarse textured soils. In most cases the use of conventional fertilizer used at the correct rate, timing, placement and form will produce satisfactory results.

Fertilizer Application

Apply fertilizer when preparing seedbeds based on soil test results. The lab or a qualified consultant can interpret soil test results and make recommendations. Fertilizer is typically applied as a fertilizer blend based on those recommendations. All fertilizer labels have three bold numbers. The first number is the amount of nitrogen (N), the second number is the amount of phosphate (P_2O_5), and the third number is the amount of potash (K_2O). These three numbers represent the primary nutrients: nitrogen (N), phosphorus (P), and potassium (K). For example, a blend labeled 10-20-20, contains 10 percent N, 20 percent P_2O_5 and 20 percent K_2O on a weight basis. If 400 pounds per acre of this fertilizer is applied to a field, the actual application will be 40 pounds of N (400 x 10 percent), 80 pounds of P_2O_5 (400 x 20 percent), and 80 pounds of K_2O (400 x 20 percent) per acre. Use fertilizer uniform in

composition, free flowing, and suitable for the application equipment being used. Fertilizer purchased will be fully labeled according to applicable state fertilizer laws.

If seeding must occur prior to obtaining soil test results and past management is indicative of low fertility levels use the following recommendations:

- For cool season grass seed mixtures, apply 40 pounds per acre of nitrogen, 80 pounds per acre phosphate and 80 pounds per acre potash. For plantings with slow establishment or sandy soils, 40 percent of the nitrogen should be in a slow release form. If the area has had previous manure application, follow soil test recommendations to avoid over application of phosphorus and the subsequent water quality concerns. Incorporate fertilizer into the top 2 to 6 inches of soil. If a soil test is pending, apply the balance of fertilizer recommended by the soil test when the results are received. If legumes are more than 20 percent of the mix, reduce nitrogen to 30 pounds per acre. Additional nitrogen fertilizer may be needed the following spring.

- For warm season grass seed mixtures, apply 60 pounds per acre phosphate and 60 pounds per acre potash. When preparing a conventional seedbed, incorporate the fertilizer into the top 2 to 6 inches of soil. Apply the balance of fertilizer recommended by the soil test when the results are received. For sterile, droughty, weed free sites when grass reaches 6 to 8 inches in height add 30 pounds per acre of a slow release nitrogen fertilizer. If weeds are problematic, it is recommended to delay application of nitrogen until the second year. For wildlife conservation plantings on agricultural soils do not apply nitrogen the establishment year, plan on applying a nitrogen fertilizer application of 50 pounds per acre the following spring. Apply nitrogen only when the plants will be actively growing when soil temperatures have warmed in late spring.

Organic Amendments

Organic materials such as compost or composted manure are often added to soils or subsoils with low organic matter or low water holding capacity to improve growing conditions. However, it takes large quantities of compost to measurably increase organic matter content of subsoils or degraded sites. Organic soil amendments such as compost or manure can be used as slow-release sources of plant nutrients. When used as fertilizer, apply manure or compost at a rate based on a nutrient analysis of the material and the soil test results. Compost sold for use as a fertilizer will be labeled for total nitrogen (N), total phosphorous (P), and total potassium (K), as well as other criteria according to state fertilizer laws. When manure or compost is applied to soil for physical and biological property improvements, do not exceed the amount of fertilizer nutrients recommended by a soil test. Consider potential water quality concerns when using or recommending organic amendments. Compost material or manure is often sold as a soil amendment without plant nutrient claims. If plant nutrient analysis is needed but not listed, the information may be available from the supplier or an analysis should be obtained. If no nutrient information is available or obtained, use state averages based on the source of the organic matter. Incorporate organic amendments into the upper 4 to 6 inches of the soil with a disk, cultivator or other suitable equipment. If approved biosolids (approved industrial and municipal sludge) are considered, follow all state and federal regulations.

Topsoil

Topsoil provides a suitable growing medium for vegetation and enhances water infiltration. Adding topsoil facilitates the increase in plant cover and biomass through an increase in nutrient availability, water holding capacity, and microbial activity. Prior to construction conduct a survey to determine the depth and quality of the topsoil and develop a plan for its utilization. Save topsoil from previously undisturbed areas on site at the beginning of construction for redistribution during final grading to provide improved planting conditions. Remove topsoil from the construction site without mixing with the underlying material and stockpile it in a mound no higher than 4 feet. Stockpiled topsoil should be stored for less than one year; preferably less than 6 months. It is best to establish a temporary plant cover on topsoil stockpiles in order to minimize erosion potential, maintain soil quality and soil microbial activity, and reduce weed species invasion on stockpiles. Mulching or using a synthetic cover will also provide some of these benefits.

Utilizing existing topsoil is both less expensive and less environmentally degrading than hauling topsoil from an alternate site, and will achieve better results than amending the subsoil. When the objective for the site is to establish excellent turf or to assure improved vegetative growth of other plant material, high quality topsoil should be brought to the site. Avoid erosion and sedimentation problems by not adding topsoil to slopes that are steeper than 2:1.

Topsoil is recommended for soils having one or more of the following limiting factors:

- Very shallow to bedrock, hardpan or other restrictive layer (e.g., less than 6 inches to subsoil)
- Extremely acidic (pH less than 4.5)
- Moderate to severe salinity (conductivity greater than 4.0 to 16.0 deciSiemens per meter (dS/m)

Borrow material can be used alone or in conjunction with topsoil to cover a site high in heavy metals or having other chemical or physical conditions that make vegetative establishment difficult.

Topsoil Quality

When purchasing topsoil, obtain soil testing information for pH, N-P-K and soluble salts. Topsoil should be friable and loamy, free of debris, stones, or other materials larger than 1.5 inches in diameter and have an organic matter content of at least 2 percent by weight. It should also be free from noxious weed seed with a limited amount of common weed seed and plant rhizomes. No toxic substances, harmful to plant growth should be included and soluble salt concentrations should not exceed 0.5 to1.0 deciSiemens per meter (dS/m). A pH of 6.5 is ideal, however, a range of 5.5 to 7.5 is acceptable. Incorporate lime with topsoil to adjust the pH to the range of 5.5 to 7.0. Visit the source or obtain a representative sample of the topsoil to assure that it is uncontaminated with subsoil or stones and is of the texture and quality desired.

Topsoil Application

Test the exposed subsoil for pH before applying topsoil. Where the subsoil is highly acidic (< 4.0), add ground limestone as per soil test recommendation or at a rate of 3 to 6 tons per acre (150 to 300 pounds per 1,000 square feet). High rates of lime application may require several years to be fully effective. Distribute lime uniformly and incorporate into the subsoil as described in the section on liming. Immediately before spreading topsoil loosen the subsoil by disking or scarifying to provide a bond with the topsoil. Where the slope of the site is less than 3:1, loosen the subsoil to a minimum average depth of 2 to 4 inches. On steeper slopes (up to 2:1), loosen the subsoil to a depth of 0.5 to 1 inch. A bulldozer may be used to track up and down the slope creating horizontal check slots that reduce topsoil from sliding down the slope. Spread topsoil only when it is dry enough to work without damaging the soil structure. Do not spread topsoil when it is partly frozen or muddy or on frozen slopes covered with ice or snow. Uniformly apply a 5 to 8 inch layer allowing for initial blending with existing soil, and lightly compact to a minimum thickness of 4 inches. Subsoil with a pH of 4.0 or less and/or containing iron sulfide should be covered with a minimum depth of 12 inches of topsoil. Topsoil placed on slopes greater than 5 percent require prompt application of lime fertilizer, seed and mulch. Adhere the mulch material to the soil by using a crimper, mulch netting or other mulch-anchoring methods.

Seeding

Seedbed Preparation

Apply necessary lime, fertilizer, and other soil amendments evenly on the site during site preparation. Prepare a firm seedbed when the soil is moist, but not wet, that is when soil moisture is between 50 to70 percent of field capacity. Field capacity is the amount of soil moisture or water content held in soil after excess water has drained away and the rate of downward movement has materially decreased. Pervious soils usually reach this state within 2 to 3 days after a soaking rain. Cultivating will destroy the physical condition of the soil when it is excessively wet. Destruction of the soils' physical condition increases soil compaction with a resultant reduction in aeration and drainage while increasing surface water runoff. Compaction impedes the movement of fertilizer nutrients, water, and air into the soil.

Slopes flatter than 3:1 need a seedbed prepared to a depth of 3 to 6 inches; this can usually be done with conventional farm equipment. Provide at least a 3-inch deep seedbed of firm friable soil free of large clods and stones. Slopes steeper than 3:1 need the soil surface scarified to loosen the soil to a minimum of 1 inch deep. Do not work completely smooth, as maintaining

a somewhat roughened condition will allow the seed to find microsites. Seed immediately following final scarification, and the ensuing rainfall disturbance will then cover the seed with soil. When possible, on steep slopes when using a bulldozer, conduct the final surface preparation by tracking perpendicular to the slope resulting in cleat marks along the contour. For wildlife conservation plantings, where slopes allow and the soils are moderately well-drained or drier, no-till seeding using a specialized no-till drill and proper weed control is an option.

Time of Seeding and Planting

The time of seeding and planting will depend on: (1) the species; (2) its growth characteristics, that is, warm season or cool season; (3) micro-climatic conditions; (4) weather at time of planting; (5) soils/site conditions; (6) form of propagule; (7) type of planting stock, that is, bare root or container (8) additional amendments used such as mulches; and/or (9) irrigation. The seeding and planting date table, based on plant hardiness zones and some of the above considerations, are given in Appendix 4a. Cool season grasses can be planted in the spring and in the fall, up to 6 weeks prior to a killing frost. August 15 to September 1 is the optimum planting time for most cool season grasses. Cool season legumes need an additional 2 to 4 weeks to obtain enough growth for winter survival. The benefits to a late summer/early fall seeding are: (1) avoidance of midsummer droughts; (2) reduced warm season annual weed emergence and competition; (3) warm season weeds that do emerge will be killed by frost; (4) favorable temperatures for growth; and (5) favorable moisture conditions. These allow seedlings to get an early start the following spring by taking advantage of soil moisture and getting a head start on any annual weeds. Late summer/early fall seeding should only be done on soils not subject to frost heaving. Warm season grasses, on the other hand, can only be seeded in the spring, due to slow initial growth. They should have 100 to 120 days of growing season to get established prior to winter. The best time to plant warm season grasses in PHZ 5 and north is the beginning of corn planting season in the area being seeded. In areas south with a longer growing season delaying planting and using labeled herbicides to kill the first flush of weeds and then using a no-till drill to seed the grasses is an often used strategy. However, in this situation there is a risk of early season drought affecting the establishment.

Dormant seeding should only be done as a last resort and should be done when soil surface temperatures will remain below those necessary to prevent germination. Protect dormant seeding sites by mulching or applying erosion control blankets. This practice will not only protect the site against erosion, it will reduce freeze-thaw cycles and protect emerging seedlings from wind desiccation in the spring. Cool season grasses and legumes should be dormant seeded just before soil freezes; warm season grasses, when temperatures at the soil surface are consistently less than 40°F. Seeding rates should be increased by 40 to 50 percent when dormant seeding, due to reduced germination, soil-borne disease, and insect predation. Fungicide seed treatments may be beneficial for dormant seedings. In the Northeast it is difficult to work the soil this late in the season due to soil moisture considerations, although hydroseeding may be an option. Consider doing a final grading or seedbed preparation earlier while the soil is at the proper soil moisture content. It may then be possible to no-till drill or broadcast and mulch if the soil surface dries enough to allow for tractor traffic.

Trees, shrubs, and other vegetatively propagated plants that are small, including bare root stock or small containerized seedlings, should not be planted in the fall where frost heaving is a concern. On well-drained soils good survival rates can be obtained by fall planting dormant deciduous trees and shrubs. Conifers, in particular, are usually not planted in the late fall without protection from desiccating wind.

Seed Quality and Treatment

Purchase and use seed that is labeled (tagged) and meets the requirements of state and federal seed laws. Information about individual state seed laws is available on state agriculture department websites or the American Seed Trade Association website. Additional information on certified seed, seed labeling and seed testing is provided in Chapter 3, "Purchasing Seed". State laws require non-certified seed to meet two-thirds of the minimum germination requirements for certified seed. Refer to Appendix 3a for examples of certified seed germination and purity requirements for some species discussed in the guide. When seed ages and germination rates drop, there is also a drop in seedling vigor. Older seed can get retested, and if it still meets state minimum germination guidelines it can be sold with the new test

date. It is best to obtain seed lots with high germination tests. If certified seed is not available, increase seeding rate using seeding recommendations based on pure live seed (PLS). For warm season grasses and wild flowers use PLS seeding rate recommendations and get cost estimates and purchase seed on a PLS basis as discussed in Chapter 3. Use seed that has had a germination test within 9 to15 months of the planting date (9 months for agricultural seeds and 15 months for turf seeds in New York). This varies by state and explicit information by state can be found at the American Seed Trade Association website. Keep seed cool and dry until planting.

Avoid seed lots with excessive dormant or hard seed; inquire as to the best seed lots available. For legume seed lots with a low germination rate and greater than 40 to 50 percent hard seed, scarify the seed prior to planting. Scarified seed should be planted within the current growing season since scarified seed's germination rate decreases quickly. In highly disturbed sites a percentage of hard seed can be beneficial for additional seedling establishment the following spring when moisture is available. Forage and turf seed can be purchased pretreated with fungicides. Some turf seed is now available with hydrophylic coatings, at an additional cost, which is reported to increase emergence. Some species of warm season grasses such as big bluestem and indiangrass and some wild flowers need extra processing to remove awns and other seed parts to help facilitate their flow through seeders, but may have a detrimental effect on their storage life.

Some native seed will have improved germination, following a cold moist period (cold stratification) typically between 34° and 41°F conducted in a plant cooler or refrigerator for a period of 4 weeks or longer. Many sources recommend using peat, a combination of peat and sand, or vermiculite as the medium for stratifying seeds. The medium must be sterile to prevent harm to the seed by pathogens including fungi; typically fungicides labeled for this purpose are used. Dormant seedings as previously discussed in this chapter can be used in lieu of cold stratification. Some species may require a warm stratification followed by cold stratification. Warm stratification requires minimum temperatures between 60 to 68°F. This requirement can also be met by planting the seeds in summer in a mulched bed for expected germination the following spring.

Legume Inoculant

Nitrogen-fixing legumes such as the clovers and birdsfoot trefoil are an important component of a vegetative community being established on critical areas, because disturbed soils typically do not contain a large reservoir of soil nitrogen. Nitrogen applied as fertilizer typically leaches out of the soil profile quite easily so having legumes in the seed mix can provide some nitrogen in the long term for all conservation seedings.

If utilizing pre-inoculated legume seed, store in a cool dry environment and use as soon as possible. Some pre-inoculated seed is encapsulated in a limestone or clay coating which reduces the amount of actual seeds per pound so seeding rates need to be increased 15 to 30 percent or as per PLS calculation to compensate. Inoculate legume seeds with species-specific viable rhizobia (nitrogen fixing) bacteria before planting. Keep inoculant as cool as possible until used and use no later than the date indicated on the package. Once inoculated, use the seed within 12 hours or re-inoculate. Use a mixing medium as discussed in the "Inoculating Legumes" section in Chapter 2 or recommended by the manufacturer to bond inoculant to the seed. Some legume seed used for forage production comes pre-inoculated.

Seeding Methods

The choice of seeding method and type of equipment depends on the: (1) site; (2) slope; (3) drainage; (4) size of area; (5) type of seed; (6) degree of final site preparation; and (7) availability of equipment. The types of seeding equipment are: (1) grass drills; (2) cultipacker-seeders; (3) hydroseeders; (4) spinner or pendulum spreaders; (5) hand mechanical spreaders; or (6) hand seeding. Grass drills can also be equipped to plant almost any type of seed; however, they cannot be used safely on steep slopes. Use hydroseeders or broadcasting equipment on slopes where the use of seed drills is dangerous. Conduct seeding operations on the contour, where possible. Plant grasses that have chaffy seed using planters with specialized seed hoppers, by hydroseeding, or by spreading with a pendulum spreader.

Carriers are used when needed to facilitate seed flow typically in broadcast-type spreaders but can also be used in drills. Carriers successfully used include dry granulated and pelleted fertilizer (without nitrogen), cracked grain, dry coarse washed sand, cat litter, pelleted or granulated lime, soybean meal, small grain seeds, and dry screened

sawdust. All carriers must be dry and flowable. Acceptable dry fertilizer grades are a good choice because they act as a carrier and provide plant nutrition. Spreaders already have calibration settings in place for fertilizer, which can be used as a starting point for calibration. A typical recommendation is to use 120 pounds per acre of granular fertilizer (without nitrogen). When using fertilizer carefully clean seeders and spreaders after use to avoid corrosion of the seeding equipment.

When broadcasting seed, to facilitate uniform distribution, divide seed (with carrier if applicable) in half and apply in two passes in perpendicular directions. When small quantities of forbs and/or fine seeded grasses are planted with larger quantities of grass seed, the forbs and/or fine seeded grasses should be divided into equal units and periodically placed and mixed into the appropriate hopper in drills or into the spreader hopper to facilitate more uniform coverage over the entire area. Calibrate all seeding equipment prior to the planting process. Refer to Appendix 3b for more information on calibration.

The use of hydroseeding with wood fiber mulch is an excellent method on steep slopes. Always consider tracking with a bulldozer to incorporate seed prior to mulching.

When slopes are too steep to incorporate the seed into the soil, use cool season grasses as the grass component of the mix. Cool season grasses tolerate lack of incorporation compared to warm season grasses, although incorporation and rolling is highly preferred. When broadcasting seed and incorporation is not possible, apply seed on freshly graded loose soil, so that a subsequent rain will wash seed into crevices and cover the seed. Mulch with straw and anchor or tack with high quality hydraulic mulch immediately following seeding to protect the site from soil erosion.

Warm Season Grasses

Warm season grass seed must have good seed to soil contact and a shallow 1/4 to 1/2 inch planting depth. Herbicides are frequently needed on former agricultural or idle land to eradicate existing perennial vegetation prior to disturbance. When you are hydroseeding or broadcasting warm season grasses on steep slopes such as gravel mines, track the site using a bulldozer or other method to insure good seed to soil contact (Figure 4f). Tracking involves driving up and down the slope, offsetting each pass to cover the entire surface with tracks. The cleats of the track should be along the contour. A site that is steep, prone to erosion and excessively well-drained may still warrant the use of warm season grasses. In that situation add non-competitive cool season grasses to the mix to provide early erosion control while the warm season grasses are establishing. Hard and sheep fescues at 5 pounds per acre or the native wildryes up to 10 pounds per acre are recommended as a nurse/companion crop when seeding warm season grasses on steep slopes. Introduced cool season forage, cool season turf grasses, or cool season legumes, however, are not recommended as a nurse or companion crop with warm season grasses. When seeding native grasses and forbs in less than ideal seedbed situations, an array of species with varying seed sizes and germination regimes is recommended. This will allow the seeds to find their niche and increase the likelihood of germination.

Seed Drills

Grass drills or cultipacker seeders are the preferred methods of seeding when the site can be worked with conventional farming equipment. Seed drills often have multiple hoppers for different size seed. These methods optimize seed to soil contact, depth control and can be calibrated to provide an accurate and uniform rate and distribution of seed resulting in uniform rows (Figure 4a). There are also several brands of native grass drills, each having features or size ranges that suit particular situations. They are typically designed for no-till seeding. No-till drills need to cut through a variety of residues, soil types and soil moisture conditions (Figure 4 b). Grasses that have chaffy seed require a drill or cultipacker seeder with a specialized seed hopper (Figure 4c). Awned (chaffy) seed may be processed to remove awns (debearded). Debearded seed used in conventional grass hoppers can still bridge above openings and clog in tubes so requires careful monitoring during the seeding operation. When debearded seed is used in specialized native drill seed hoppers, the seed may now flow faster than anticipated which poses problems when calibrating for low seeding rates. Always calibrate seeding equipment using a sample of the actual seed purchased and with any carrier planned for use. Mixing with a carrier can be used to help obtain better distribution of small seeded species. Small seeded grass and legume seeds should be planted no more than 1/4 to 1/2 inch deep. Some drills have depth bands (Figure 4d) on coulters to facilitate proper depth control. When conventional tillage is used, it is desirable

Figure 4a. The use of a drill has uniformly distributed the seed in rows, providing good seed soil contact and uniform seeding depth.

Figure 4b. A heavy no-till drill can cut through residue.

Figure 4c. Native grass hoppers with mechanism to draw seed over openings and picker wheel to pull seed down the tube.

Figure 4d. Depth bands help to prevent planting too deep in soft or tilled soil.

to cultipack prior to using heavy seed drills meant for no-till applications to avoid planting too deep. Drills without a packer attachment should be cultipacked or rolled following planting. When applying fertilizer in seeders or spreaders, promptly and thoroughly clean the fertilizer hopper or spreader after each use to prevent corrosion.

Desirable features in native grass drills:

- Chaffy seed box, small grain box and a legume box
- Seed agitator and picker wheel feed in the chaffy seed box
- Large drop tubes (2″ diameter min.) from the chaffy box to the row openers
- Straight drop from the chaffy seed box to the row openers
- Double disc row openers with removable/adjustable depth bands used for depth control
- Convenient calibration and depth control systems
- Adjustable pressure packer wheels for closing seed furrow
- Sturdy and heavy frame
- Brackets to add weights for penetrating firm soil

Broadcast Seeding

Seed can be broadcast using broadcast seeder/spreaders such as conventional spinner type seeders, pendulum spreaders (Figure 4e), and mechanical hand seeders or can be broadcast by hand. When broadcasting, divide the seed in half and apply in two passes in perpendicular directions. When broadcasting, small or light-seeded species may be mixed with a filler (e.g., sand, sawdust, rice, cat litter) to achieve an even distribution. Hand seeders that have native grass seeding capability are

Figure 4e. The pendulum broadcast seeder's rapid oscillating arm allows for all types of seed and carriers to be dispersed.

Figure 4f. Bulldozer cleats track in seed and provides good seed soil contact.

commercially available. Incorporate seed 1/4 to 1/2 inch deep by raking, dragging, cultipacking, or tracking with a bull dozer (Figure 4f). Roll raked areas with a weighted roller or cultipacker to provide good seed to soil contact. It is important to increase seeding rates by 25 percent when broadcasting due to variability in seeding depth. When broadcasting with little seedbed preparation and no tracking increase seeding rates by to 50 to 75 percent. This attempts to compensate for the inability of seed to germinate or the loss of seed to predators. Manual broadcast seeding offers the opportunity to spot-seed microsites using different seeding rates and seed mixes.

Hydroseeding

Hydroseeding is a type of broadcast seeding that distributes seed, soil amendments, and mulch in a suspension of water. It is best suited for steep (> 2:1) slopes or inaccessible areas where a drill or other mechanized equipment is not feasible. Hydroseeding equipment contains a continuous agitation system keeping all the materials in uniform suspension throughout the mixing and distribution cycles. Seed that is left in the hydroseeder tank for periods of over one hour can be damaged by the fertilizer and the tank agitator. Centrifugual 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 may be difficult or damaging to use the hydroseeder to apply the required amount of lime needed to amend the soil profile due to abrasion, settling, and the handling of large amounts of bagged or bulk lime. Spread lime prior to hydroseeding. A small amount of specialized liming material is sometimes used to adjust the slurry pH when seeding legumes. Do not use burnt or hydrated lime in the hydroseeder. Hydraulic mulches are an integral part of hydroseeding. Mulch products include cellulose fiber mulch (paper), wood fiber mulch, blended (cellulose and wood) or bonded fiber matrix. Pure cellulose mulch is not recommended for steep slopes. A discussion on hydraulic mulches is covered later in the chapter.

Hydroseeding Cool Season Grasses/Turf Establishment

A two-step method is most effective in which seed, soil amendments and 5 to 10 percent of the total fiber mulch are used as a carrier/marker and are applied in the first pass. The balance of wood or cellulose fiber mulch and tackifier or bonded fiber matrix are applied in the second pass covering the seed. Seeding outside of the optimum window is not recommended but if unavoidable, mitigate by increasing seeding rates by 25 to 50 percent and applying clean weed free straw at a rate of 2,000 pounds per acre. Then tack down with 500 to 750 pounds per acre of fiber mulch making sure the site is protected from erosion. Reseeding will often be necessary and some follow up measures should be planned for.

Hydroseeding Warm Season Grasses

The most productive method for hydroseeding warm season grasses involves three separate operations:

- The seed, soil amendments and 5 to10 percent of the total fiber mulch are applied in the first pass.
- The seeded area is then incorporated with a cultipacker, roller, or bulldozer cleats, to improve seed to soil contact (Figure 4f).
- The balance of the mulch plus tackifier or bonded fiber matrixes is applied in the third pass.

This three-step method insures that seed has good soil contact and is not embedded in the fiber mulch.

When using a hydraulic seeder, chaffy (awned) seed such as bluestems, indiangrass, or sideoats grama must be added to the mix very slowly in small portions to prevent clumping.

Hydroseeding Legumes

Legumes included in the seed mixture require species-specific inoculation. The survival of these inoculant bacteria can be affected by the chemical characteristics of the hydroseeder slurry, therefore add the inoculant to the slurry just prior to spraying and add four times the rate recommended when using a seed drill. A small amount of hydroseeding liming product or pulverized limestone passing through at least a 200-mesh sieve added to the mix may improve the survival of the rhizobia bacteria and the subsequent ability of the hydroseeded legumes to fix nitrogen. Legumes typically need higher soil pH for long term survival and applying enough lime through the hydroseeder to correct most low pH soils is not feasible. Legumes are more sensitive to fertilizer soluble salt concentrations than grasses so it is important that fertilizer recommendations take this into consideration. Fertilizer can be added as a separate operation or additional fertilizer can be added once the seeding has become established if needed.

Temporary Seeding

When the period of soil exposure is more than 2 months but less than 12 months, mulch and seed should be used for temporary cover to provide short-term protection on disturbed areas. Temporary seeding and mulching should be considered so the permanent seeding can be conducted at the appropriate seeding date. Refer to Appendix 4b for rates and timing of temporary covers. When a temporary or permanent seeding cannot be completed mulch only (no seeding) should be applied as a temporary cover when soil stabilization is needed. Refer to the "Mulching" section for application rates and methods.

Nurse Crops and Companion Plants

Species used for temporary seeding can be used as nurse crops and should be selected based on season of planting. Nurse crops are planted with a permanent seeding mixture when rapidly growing cover is needed due to erosion concerns or when seeding toward the end of the effective planting dates in the fall. Refer to Appendix 4b for rates and timing of nurse crops and companion plants. It is important to reduce seeding rates from the temporary cover rates, so nurse crops do not over-compete with permanent seeding. Seed nurse crops of small grains (such as barley, wheat, oats, or cereal rye) at one-third the rates typically used for grain production or total temporary cover. For warm season grasses, when a nurse crop is necessary, oats are recommended but should not exceed 20 pounds per acre.

Companion plants are typically perennial fast growing species that are included in small amounts in the mix. When very small-seeded grasses such as red top are included do not exceed 1-2 pounds per acre. Perennial ryegrass should not exceed 10 pounds per acre. Hard fescue and wildryes seeded at 5 and10 pounds per acre respectively are recommended as short-term companion crops for warm season grasses.

Permanent Seeding

Permanent seeding species and rates should be selected based on conservation objectives and site characteristics. The seeding recommendations given in the appendices are focused on erosion control with some seeding mixes having dual purpose for wildlife planting. In general, for wildlife plantings where erosion control is not a concern and species diversity including volunteer vegetation is acceptable lower seeding rates could be used. Refer to wildlife seeding mixtures in the NRCS Electronic Field Office Technical Guide, Section 1, for example in New York, Plant Materials Technote-36.

Grass and Legume Seed Mixes

Grasses and legumes suitable for critical area planting in the Northeast are described in Chapter 2 and Appendices 2b-2h. To aid in selecting seed mixes two tables were constructed. The first table in Appendix 4c lists a variety

of applications and purposes for establishing permanent seedings, for example, dams and embankments or sand and gravel pits. In Appendix 4c, adjacent to those purposes several seed mixes are listed by number (1 - 25) representing the 25 seed mixes described in Appendix 4d. Appendix 4d lists the 25 seed mixes, their seeding rates per acre, seeds per square foot and their suitability based on their soil drainage classification and shade tolerance. An active spread sheet of the seed mixes is available on the USDA-NRCS Big Flats Plant Materials Center website and is designed so that when seeding rates in pounds per acre are changed, the seeds per square foot for the species and the total for the mix will change to assist in modifying mixes if needed. The Conservation Seed Calculator in Appendix 2j available on the Big Flats Plant Materials Center website is designed so custom mixes can be developed for most of the species in the guide. Both the percent of each species by the PLS pounds per acre and by their PLS seeds per square foot can be viewed. Seed mixes are developed based on the characteristics of the species and their ability to establish and co-exist with each other. Soil adaptation, seeds per pound, seedling vigor, seed spread, vegetative spread, shade tolerance, and height and vigor of the mature plant all play a role in their compatibility.

Wildflowers

Weed control is the largest obstacle for successful large acreage seeding of wildflowers. Controlling weeds prior to seeding wildflowers is very important and every effort should be made to eliminate existing perennial weeds, sod forming cool season grasses, and the weed seed bank. Mowing the second year may be necessary if annual weeds become a problem. There are very few herbicides listed for spraying over wildflowers and many states have none. Once broadleaf perennial weeds invade a wildflower planting, there are not many control options other than spot spraying and hand weeding.

Establishing wildflowers directly from seed is challenging. Native wildflowers are usually unimproved germplasm with little or no selection for seedling vigor or resistance to insects and diseases. Characteristics such as pollinator rating, heights, flowering dates, and ease of establishment, for 60 species of wildflowers, are provided in Appendix 2i. Not all of the species listed and discussed below are rated high for pollinator enhancement but may be suited in mixes for critical area plantings.

Research was initiated on the establishment of wildflowers at the Big Flats Plant Materials Center in 2009. We have found that the actual germination of wildflowers is not the issue. Many of the species listed in Appendix 2i readily germinated without stratification, although the legumes did require scarification. Species that germinated quickly, in the first year, in the field studies include: evening primrose, perennial blue flax (non-native), hoary vervain, early goldenrod, gray goldenrod, hairy beardtongue, tall white beardtongue, swamp milkweed, partridge pea, lanced leaved coreopsis, plains coreopsis, showy tick trefoil, purple coneflower, round headed lespedeza, wild bergamot, purple bergamot, spotted bee balm, gray headed coneflower, black eyed Susan, ashy sunflower, calico aster, hairy white old field aster (heath aster), Virginia mountain mint, and blue false indigo. Some of these species have improved germination when they are given a cold-moist stratification.

Other species in the table which germinated and significantly increased in numbers the following year included: giant sunflower, New York aster, smooth blue aster, flat top white aster, New England aster, zigzag aster, bigleaf aster, ox eye sunflower, wingstem, grass-leaved goldenrod, showy goldenrod, bluestem goldenrod, common sneeze weed, and great blue lobelia. Greenhouse trials have shown that goldenrods, asters and other species with extremely small seeds benefit from being surface sown.

A few of the species which did germinate, had poor seedling vigor or slow initial growth and are declining due to heavy weed competition or insect and disease problems. These include: butterfly milkweed, common milkweed, lupine, marsh blazing star, white turtlehead, wild senna, spiderworts, Culver's root, and the vervains. For these species establishment by container grown plants would be more successful.

Some species mentioned above have shown some potential to become invasive if not seeded in low numbers. These include hairy white oldfield aster, partridge pea, and black eyed Susan.

Wildflowers can be used to augment native grass plantings or used as the primary component for a pollinator enhancement planting. For pollinator mixes use no less than 75 percent wildflowers, as measured in PLS seeds per square foot, with the remainder being unaggressive, bunch grasses. To add diversity and color to

other wildlife plantings 15 percent of the mix as measured in PLS seeds per square foot should be in wildflowers. This creates a natural mosaic for a more diverse wildlife habitat.

The native grasses typically used as companion plants for pollinator seedings are little bluestem on well-drained sites and wildryes on areas with more moisture.

The time of year in which to seed wildflowers is being investigated in the Northeast and may be dependent on soils and species. There are three periods in which a seeding can be conducted; in the spring, late summer, and as a dormant seeding. A spring seeding will usually have more annual weeds than a late summer seeding and will require a strict regimen of mowing. Little bluestem, wildryes, and, for some applications hard fescue, a non-native species, can be seeded in the spring. A late summer seeding, in early to mid August, may work on well-drained soils but not on soils subject to frost heaving. Little bluestem, a warm season grass, can not be established at this time of year but wildryes and hard fescue can be substituted at a rate of no more than 5 pounds per acre. Dormant seedings are subject to soil-borne diseases and insect predation over the winter and early spring. Working the soil, at the proper time, may be a challenge in the Northeast, if a dormant seeding is being utilized. This is the least recommended method. The most important part to a successful wildflower planting is weed control to eliminate perennial weeds and weed seed in the soil, this may take several years to accomplish correctly.

Wildflowers have a wide level of variability in seeds per pound, shade tolerance, seedling vigor, seed and vegetative spread, soil tolerances, size of mature plant, and life cycle (annual, biennial or perennial). These factors, along with the high cost of seed of some species, need to be taken into consideration when designing seed mixes. Some wildflowers are prolific seeders and can dominate the stand so it is important not to overplant those species. Custom mixes can be developed using the seed calculator depicted in Appendix 2j. Two pollinator mixes, one for dry and wet soil types were developed using the calculator. The Conservation Seeding Calculator will be available on the USDA-NRCS Big Flats Plant Materials Center website. More information about wildflowers for pollinator enhancement and additional recommended seed mixes for the Northeast, is available on the Xerces Society website.

Since some seed of wildflowers are very expensive and the availability and seed prices vary from year to year, the estimated prices in the table should only be used as a guide for planning seed mixes. The prices currently listed are estimates based on 2011 pricing for bulk seed. Be cognizant as to how the seed is listed in the catalog, most wildflower seed is listed in bulk, not PLS. If you order in PLS get a cost estimate since you will get more bulk seed and the price for your order could increase significantly.

Supplemental Watering

Mulch is always recommended for a new seeding, especially if a soil moisture deficiency is anticipated. Do not allow soil to dry out until vegetation is well established, this may require daily watering up to 1/4 inch per day. Recommendations for turf grass are to keep the seedbed moist, but not saturated, to a depth of 1 to 2 inches until seedlings are 1/4 to 1/2 inch tall. This is especially necessary when the seeding is done in abnormally hot or dry weather, or on droughty soils. Irrigation requires knowledge of water management from pipelines and application rates and timing. Irrigation induced erosion on slopes is a frequent concern.

Mulching

The term "mulch" covers a broad array of materials used to provide an instant cover over the ground to protect the soil from erosion and to improve conditions for seed germination and plant growth.

Mulching should be standard practice on critical area plantings, especially on difficult sites such as steep slopes, subsoils, and excessively dry soils. The steeper the slope and the poorer the soil, the more valuable it becomes. Apply mulch immediately following seeding or planting. On larger sites the mulching operation should follow the planting operation as it moves across the area so that delays are not occurring between the two procedures. Mulch is a tool for revegetation, since ultimately the plants, not the mulch, are expected to stabilize the site. Plant growth is the first goal. Mulch prevents erosion in the same manner as vegetation, by protecting the surface from raindrop impact and by reducing the velocity of overland flow. Mulch needs to be applied with a density that protects the soil from erosion while allowing water and light to penetrate and seedlings to emerge. Mulches are not a substitute for water control practices; water run-on from adjacent land or from seepage should be controlled with engineered water control structures or grading during site preparation.

Mulch is used for one or more of the following purposes:

- Provide temporary erosion control in lieu of temporary seeding when seeding must be delayed until the proper planting dates, or until seedings or plantings become well established
- Conserve soil moisture to aid seed germination and plant survival
- Reduce surface compaction or crusting, and improve water infiltration
- Protect soil from water and wind erosion
- Reduce weed pressure on the planted vegetation
- Moderate the fluctuation of temperature at the soil surface
- Reduce frost heaving
- Add organic matter
- Protect surface applied seed from birds and other consumers

Soils that are mulched stay cool and moist for longer periods in the spring. This is a positive benefit to cool season grasses, legumes, and woody plants as they establish root systems and begin growth. The seeds of warm season grass and some of the native wildflowers have evolved to germinate under the warmer conditions of early summer. Thus mulches tend to delay and prolong the germination process for those plants, elevating the risk of failure. If mulch needs to be used, reduce rates to 1,000 pounds per acre to allow for sunlight penetration to the soil surface.

Use mulch consisting of natural and/or artificial non-toxic materials. These include coconut fibers, wood shavings, straw, hay, bark chips, plastic, or fabric. Use straw in place of mulch hay for most applications where introduction of weed seeds from the hay is a concern. Mulch must be of sufficient thickness and durability to achieve the desired effect for the required time period. Use tackifiers, emulsions, netting, pinning, or other methods of anchoring mulch in place until it is no longer needed. There are many products available today for performing specific tasks that may be considered as mulches. Specifications for existing products are available from the manufacturers. Refer to Appendix 4e for a summary table of mulch materials, rates, and uses.

Types of Mulch

Straw: Apply clean, dry straw for mulching where the benefit to plant growth is the primary consideration. Clean straw contains no noxious weeds, minimal weed seed, minimal dust or mold and minimal grain seed. Straw can be from the cereal grains: oats, wheat, barley, rye or triticale. Apply straw mulch at the rate of 2 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 (Figure 4g). This provides erosion protection and allows adequate light penetration for seedling germination and emergence. For most applications the straw should be immediately anchored after placement (Figures 4h and 4i) to avoid mulch being moved by wind or water. Refer to the section below on mulch netting, crimping, and tacking. 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: Hay is an acceptable alternative to straw only if weed seed content does not affect the site objectives as weed and forage crop seed can overwhelm the desired vegetation. If the introduction of weeds is an issue, for example, native warm season grass establishment or in ecologically sensitive areas, use straw in place of hay. Hay tends to break down faster than straw so heavier rates may be required and it also requires anchoring on sites subject to wind. Furthermore, it is more likely to contain mold that can be an allergy problem for workers on site.

Manure: Manures are usually used as a soil amendment to add organic matter. Composted manure is available in some locations although it is highly variable in its starting material, the methods used for mixing and the composting temperature reached. If compost reaches a high enough temperature, there is a reduction in viable weed seeds.

Bark and Wood Chip Mulch

Apply shredded hardwood bark mulch, bark chips or woodchips to a depth of 2 to 4 inches around plantings of trees, shrubs, groundcovers, and vines. The bark and wood should be pulled away from the trunk of the trees or shrubs. Shredded hardwood bark mulch, rather than bark chips, is used on steeper slopes because it is less subject to movement by water. Avoid incorporating bark and wood mulch into the soil. Incorporated mulch can cause nitrogen to be tied up by microorganisms breaking down the mulch.

Figure 4g. Mulch should be applied at a density of 85 percent cover to hold moisture but allow for seedlings to emerge.

Figure 4h. Straw mulch needs to be held in place to prevent movement from wind especially if chopped. Photo by John Price, Price and Company.

Figure 4i. Fiber mulch with tackifier can tack down straw and maintain good mulch density. Photo by John Price, Price and Company.

Hydraulic Mulch Types

Hydraulic mulch consists of cellulose (paper), shredded wood fiber, blended (wood and cellulose) or bonded fiber matrix. They are used with tackifiers to adhere the mulch to the soil surface and a dye to provide visual aid during application. They are used at rates from 2,000 to 4,000 pounds per acre depending on the material, additives, soil/site conditions and time of planting. Hydraulic mulches are short lived. Based on application rate and material used they usually last from 3 to 12 months and are therefore used to temporarily protect exposed soil from erosion by wind, raindrop impact and sheet flow while seeding becomes established. Additives can be used to extend their longevity. Hydraulic mulches are mixed in standard hydraulic mulching equipment (hydroseeder) to form a homogenous slurry and are continuously agitated. All wood fiber based mulches need mechanical paddle agitated equipment. This 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 manufactured from recycled newspaper, magazines, or other paper. Cellulose fiber is the least expensive fiber mulch and is primarily used to tack straw at 500 to 750 pounds per acre with a tackifier. It usually comes in bales but it also comes in pelletized forms for easier pouring into hydroseeders but is more expensive. It can also be used as a mulch on flat surfaces for turf applications at 1,500 pounds per acre to aid with germination during optimum seeding windows. Do not over apply cellulose mulch since it can create a consistency of papier maché reducing infiltration and air exchange, inhibiting seed germination and establishment. Therefore it is better to use a mixture of wood and cellulose fiber mulch when erosion control is a concern. Expected longevity for cellulose fiber mulch is no more than 3 months.

Wood fiber mulch manufactured from recycled wood or virgin wood fibers is typically applied with tackifiers. Wood fiber mulches retain water with interlocking fibers and are used to control erosion for slopes up to 3:1. Expected longevity is 3 to12 months.

Blended wood/paper mulches are 50 percent to 70 percent wood fiber, 30 percent to 50 percent paper fiber.

Blending allows a contractor to have a product that is easy to mix and 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 use either wood fiber or bonded fiber matrix type mulches with tackifiers. Expected longevity is 3 to12 months.

Bonded fiber matrix (BFM) is a continuous layer/matrix of elongated wood fiber strands held together by water-resistant bonding agents such as soil flocculants, cross-linked hydro-colloidal polymers, or cross-linked tackifiers. It forms a lofty, interlocking matrix which creates air space and water absorbing cavities that improves seed germination, reduces the impact of raindrop energy, and minimizes soil loss. BFM may be used on slopes up to and including 2:1. Do not apply immediately before, during or immediately after a rainfall, or if the soil is saturated as it typically requires 24 hours to dry before rainfall occurs in order to be effective against erosion. Expected longevity is 3-12 months.

Mechanically bonded fiber matrix (MBFM) is produced from strands of elongated wood fibers and crimped synthetic fibers to create an interlocking mechanism between the fibers. This material is combined with additional binding agents. MBFM may be used on slopes up to and including 2:1 and provides immediate protection against erosion since no cure time is required to develop surface protection. Expected longevity is 12 months or greater.

There are many products on the market that blend the different materials described above. These products will have variable curing times, application rates, degree of protection, and cost. It is imperative that the user follow all manufacturer's recommendations for a specific site condition when applying materials.

Soil Stabilization Matting

Erosion control matting, rolled erosion control blankets, and turf re-enforcement mats are types of erosion control products which are rolled out on site for immediate erosion protection. Some mats are specifically designed to handle higher velocities in concentrated water flow areas (Figure 4j). These typically have straw or coconut fiber mulch between layers of jute (biodegradable), UV degradable or non-degradable netting. They are designed for many applications for a variety of slopes, velocity, and years of service. They are installed up and down the slope never on the contour. Some products are made of a non-degradable fiber layer with 95 percent pore space allowing for hydraulic seeding over the top for more structure. They need to be applied to obtain a firm continuous contact between the material and the soil and adequately stapled according to the manufacturer's recommendations. These materials vary in cost based on longevity and are typically more expensive than most of the hydraulic mulching options.

Figure 4j. Erosion control matting can withstand higher velocities of water than most hydraulic mulches.

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.

Crimper

A tractor-drawn mulch anchoring coulter (crimper) is used to push mulch into the soil surface to anchor part of the mulch and leave part standing upright. When crimping mulch follow the general contours of the site and do not cut the straw. Farm disks are a poor substitute as they tend to cut the mulch and turn over the soil due to the concave form of the disk. Crimping operations are limited to areas accessible by tractor unless the implement is pulled by a small bulldozer. As a last resort, crimping can also be done by bulldozers traveling up and down the slope so that cleats are crimping along the contour.

Mulch Tackifiers and Binders

Tackifiers are sticking agents sometimes used independent of mulch to temporarily bind soil particles together and protect the surface from wind and water erosion. When applied with hydraulic mulch, tackifiers increase the effectiveness of the mulch as a soil cover by binding the mulch fibers and the surface soil particles together. For tacking straw at least 500 pounds per acre of fiber mulch is added. Two types of tackifiers are currently available, organic and polyacrylamide polymers. Organic tackifiers are usually made from guar gum, plantago, or corn and potato starches and are best used for flat to moderate slopes. Their holding ability and effective longevity is determined by the quantity added to the slurry, but are usually viewed as short-lived. Polyacrylamide (PAM) tackifiers last longer, are UV degradable and although applied at lower rates will produce the same or more holding ability as organic tackifiers. PAM tackifiers help bind soil particles together. It is important to use water-soluble anionic PAM labeled for this application. Organic and polyacrylamide tackifiers may be applied in the hydroseeding mix with excellent results. Tackifiers not only aid in bonding the application, they also "slick up" the slurry, reducing or eliminating clogs in hoses.

Inspection and Maintenance of Seeding

Inspect the seeding at least 3 weeks following the seeding, evaluate for weeds, and plan and implement all necessary weed control treatments. The success of any seeding will depend on the weed control during the establishment period. Additional inspections are needed following major rain events and periodically during the establishment year especially for seedings on steep slopes or areas with expected high velocity and volumes of concentrated water. Repair areas by reseeding and mulching where erosion is evident. Where there has been some movement in erosion control matting reinstall and staple as needed. Care should be taken to minimize the damage to protected areas recently established while making repairs. In critical area seedings the soil conditions are not as uniform as in an agricultural seeding leading to variability in establishment. Evaluate the growth of the seeding and check if there are areas under stress due to lack of fertility. If this is the case, spot applications of fertilizer may be necessary. This lack of uniformity may show up as moisture stress and additional mulching or irrigation may be necessary. In some high-priority areas irrigation should be initially used over the entire area to achieve the intended results. In some areas due to soil variability or poor grading excess soil moisture may be the concern.

Stand Evaluation

When evaluating a seeding it is important to consider the conservation objectives and site conditions. Permanent herbaceous vegetation is designed to achieve a minimum density of 85 percent ground cover within one year. Turf seedings are typically conducted on better soils than critical area seedings. A turf seeding conducted on good soil, amended with topsoil, with proper pH and fertility could result in a very high seedling density up to 6 seedlings per square inch. Critical area and conservation plantings are seeded on more marginal conditions with less management and lower seeding rates with lower seedling densities anticipated. For some wildlife habitat seedings a dense seeding is not desirable. Wildlife and erosion control plantings need to grow much taller than turf plantings, so individual plant vigor is important. There is a relationship between individual plant size and rooting depth. Bigger plants root more deeply and are more drought tolerant and productive.

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.

Herbaceous Plants for Conservation Plantings

Herbaceous Plant Material

Grasses, sedges, and wildflowers are planted for conservation purposes such as pollinator gardens, rain gardens, wetland enhancement, and for erosion control. Chapter 2 describes and references many species for these applications. Some species are planted for low maintenance landscape plantings or in areas where maintenance mowing is not feasible. A report prepared by Cornell University for the New York DOT, Plant Materials for Vegetation Management along New York State Roadsides lists many native and non-native plants for this application. Some species are difficult to establish by seed or the seed is very expensive so transplanting is a way to increase species diversity and allow for potential future seed dispersal. Be cautious of using species that have aggressive growth habits or produce abundant seeds that readily germinate and may spread beyond the planted area. This is especially important if the planting is near a neighboring property or a natural area such as a shoreline or woodland. Considerations should also include the time, labor and expense that will be needed to maintain the planting due to supplemental irrigation, protective cages, and other measures needed to insure long term survival.

Plugs or tublings 5 to 8 inches or greater in depth are more reliable for direct planting on landscape and restoration projects than smaller stock (Figures 4k and 4l). Larger containers (i.e., gallon) typically used for landscaping projects can be used for small projects, but when used in large numbers increase the cost and labor significantly. Information regarding purchasing herbaceous plants is provided in Chapter 3.

Plant plugs in well-prepared sites where all the existing vegetation has been killed and the weed seed bank has been reduced. This may take two or more years. Prepare soil by incorporating 2 inches of compost or peat moss into the upper 6 to 8 inches. Incorporate lime and fertilizer based on a soil test. In the absence of a soil test, fertilizer may be added at the rate of 1 pound of 10-10-10 grade fertilizer (or equivalent) per 100 square feet and monitored for additional fertilizer needs later in season. Consider using slow release fertilizer following manufacturer's

Figure. 4k.The Rootrainer tray is easy to transport and handle prior to and during planting.

Figure. 4l. The Rootrainer-type system is an effective way to grow vegetative plugs with minimal disturbance to the root system when removing from the container.

recommendations. It is important to control weeds while plugs are getting established using landscape weed fabric or pre-emergence herbicides that prevent all weed seeds from germinating. Follow herbicide recommendation from a qualified consultant and follow all manufacturer's labeling for the state in which the planting will be conducted. Keep plugs moist and protected while in transit and on the site prior to planting. Plant warm season grass and herbaceous perennial plugs in mid to late spring after the ground has warmed sufficiently for good root growth, but while adequate rainfall and soil moisture can still be expected. Avoid planting plugs on soils with poor drainage in the late fall, when alternate freezing and thawing can result in heaving of plugs that have not been fully established. Plugs should be planted on 12 to18 inch spacing for most species depending on their potential for vegetative spread. Closer spacing provides more immediate cover and reduces the need for as much weed control. Wider spacing covers a larger area with the same number of plugs, however weed control will be required for a longer time. Planting holes should be to the depth of the plug root mass. Plant each plug so the top of the root mass is level with the surface and the potting medium is covered with existing soil to prevent wicking. To limit backfill material from drying out, be sure to plant within 2 to 3 minutes of digging the hole. Water plugs at time of planting to settle the soil and rewet potting medium, then as needed during the establishment period. Check to make sure the plug is fully covered following watering in and settling. Apply mulch for erosion and weed control, soil moisture retention and to reduce frost heaving.

Planting can be in combination with direct seeding to fill in areas and increase species diversity. Seed those species that will germinate and establish easily from seed and then, after weeds are under control and the seeding is well established, plant plugs for the other species that have a more difficult time establishing from seed. Sods of native plants and forbs can be an option in areas prone to erosion.

Vegetatively Established Grasses for Erosion Control

Some grasses are established using vegetative propagules. These species are typically used for specialized situation around sand dunes and tidal banks. For additional information about revegetating sand dunes and tidal banks refer to the Cape May Plant Materials website and the New York Department of Environmental Conservation Standards and Specifications for erosion and sediment control, Vegetating Sand Dunes and Tidal Banks web page. More descriptions and information about these grasses are described in Chapter 2 and Appendix 2e.

Prairie cordgrass is planted adjacent to fresh water ecosystems. Planting by rhizomes is more successful than by seed especially in critical areas. It has an extensive root system (Figure 2a), which can be dug when dormant, and either planted dormant or transplanted into pots then planted after the root system becomes re-established. Place plants 12 to 24 inches apart depending on severity of site.

American beachgrass is the best species for the initial stabilization of frontal sand dunes. Beachgrass is normally planted by hand spade or with a beachgrass/tree planter. In either case, the requirement is to get the base of the culm (stem divisions) deep enough, usually 8 inches below the surface. It is important that beachgrass culms are dormant when planted and kept cool and moist during the planting procedure. Beachgrass should be planted when the soil is not frozen during the period from October 1 to April 30th. Plant 2 to 3 culms per hole, 12 to 24 inches apart, depending on severity of the site. Apply 30 to 40 pounds of slow release nitrogen fertilizer per acre annually in early spring until desired density is obtained. For sand dune planting, the row closest to the ocean should be at least 100 feet above the mean high tide line. Preferably, they should be planted in a strip 40 to 50 feet wide but no less than 20 feet wide and 10 rows deep. This permits the planting to trap blowing sand, and to build or protect a dune. The grass responds to being buried by sand and once established it rapidly spreads by a rhizomatous root system, developing a soil-binding network of inter-woven roots. Beachgrass is frequently planted in conjunction with sand (snow) fencing. Pedestrian and vehicular traffic should be excluded since their impact will seriously damage and kill the plants. Fertilize if stands should start to weaken. and replant open areas as they develop.

American beachgrass can be used on droughty inland sites for temporary erosion control as vegetative terraces planted along the contour or perpendicular to the prevailing wind direction with a seeding between rows. Do not plant "Cape" American beachgrass along the Great Lakes or Lake Champlain. Use local ecotypes for these areas.

Smooth cordgrass plants should be planted at the mid-point between the high and low-tide elevation in brackish water. Planted along the shoreline, smooth cordgrass absorbs the wave energy and collects the sediment brought in by the water. As the sediment is dropped, the band of vegetation expands pushing the mean high tide away from the toe of the bank. Smooth cordgrass is usually propagated using vegetative stem divisions in late spring. Depending on the energy effecting the planting site, either containerized (for high-impact sites) or bare root (for mild impact sites) plants can be utilized. Containerized seedlings should be about 12 inches tall with 3 to 5 stems per container. If transplanting bare root stock from natural or cultivated stands they should be harvested from open stands when the top growth is 6 to 10 inches tall. It is essential that the plant be placed at the proper depth with the planting hole tightly closed so that it will not float out with the tides. On sites with a high wave energy problem, the addition of an anchor made of 1/4 inch rebar 30 inches long bent into a hook to secure the plants may be needed. Since most marsh sites are irregular and difficult to access, hand planting is normally employed using spades, dibbles, or planting bars. Plant spacing should be between 18 and 72 inches. If 2 rows are used, the rows are spaced 5 feet apart. Lateral spread of 2 to 10 feet can be expected annually. Following planting, protect the site for the first growing season with a perimeter fence. This is especially important if the area is known to be frequented by swans or Canadian geese.

Saltmeadow cordgrass is adapted to both the secondary and back dune moist locations as well as the tidal marsh estuary. Saltmeadow cordgrass grows in dense stands in open tidal marshes from the normal high tide line to about 10 feet above the shoreline. Saltmeadow cordgrass is planted using potted plants of a similar size as smooth cordgrass. Bare root stock can be planted but the performance is not as good as with smooth cordgrass. Place plants 12 to 24 inches apart, depending on the severity of the site, and 6 to 8 inches deep (deeper in moist soil). Saltmeadow cordgrass is usually planted above the smooth cordgrass from mean high water to the toe of the slope.

Grasses for turf that are sprigged, such as bermudagrass or zoysiagrass, are either hand planted on small areas or planted with specialized machinery. Sprigging is a shallow planting method, and dormant stock must be used. Provisions for immediate and frequent watering are imperative. These species are not planted north of PHZ 6.

Wetland plants are sold as plugs, bare root, sprigs, rhizomes and/or tubers due to a lack of seed production or the expense of the seed. They may be difficult to establish by seed due to poor seedling vigor and/or dormancy issues. Species should be selected to be planted in hydrologic zones (water depth or inundation periods) for which they are adapted. Those selected for restoring a wetland community should be representative of species occurring nearby in similar wetland communities.

Plantings can be augmented with seed mixes appropriate for the site. In areas not suitable for traditional cultivation and seeding equipment, seed immediately after construction while the soil is still loose. Do not grade smoothly, maintaining a relatively rough seedbed allows for variability in microtopography to provide niches for the seed. Use diverse mixes with varying germination requirements suitable for variable hydrology and topography. If the soil is not already compacted or crusted, rain will wash the seed into the soil crevices. Use a broadcast spreader, hydroseeder, seed drill or hand seed when the water table is drawn down. It is not practical to seed any wetland where the water is more than 2 inches deep or where severe flooding is likely to occur before germination. The same caution applies to mulching. Often, natural seed banks (seeds in wetland soil) will establish part of the vegetation cover. There are commercial mixes available from native seed companies.

Moving Wild Plants from a Donor Site

It may be advantageous to collect plant material from nearby wetlands, streambanks, and riparian areas to be used in restoration projects. Easier to move herbaceous plants and some shrubs like willows, alders, and dogwoods are typically chosen for collection. These shrub species are more often collected by harvesting dormant, unrooted cuttings or whips. All necessary permits required for collecting or moving plant material must be obtained in advance. Caution must be stressed to avoid permanent damage to the donor site. Factors to consider when moving plants from local donor sites:

- Ecotypes adapted to the local environment may be collected.
- There must be minimal risk to the integrity of the local gene pool.

- A wider diversity of plants may be available than from nurseries.
- Plants may be collected as needed, eliminating the need for extended storage.
- Time must be allocated to locate nearby areas suitable for collection.
- Weedy species may be inadvertently transplanted to the project site.
- Rare plants at the donor site may be harvested or damaged.
- Plants from the donor site may be stressed, diseased, or insect infested.
- Logistics of digging and moving suitable material may be complicated.
- Cost of collection may be high if heavy equipment is needed to dig and lift heavy material and large trucks are required to move the material.
- Significant handwork may be required to separate rhizomes and individual plants before transplanting.
- Cost of the plant material will increase as the distance from the site to be restored increases.
- The donor site may be susceptible to invasive plant encroachment after disturbance.

Obtaining trees from donor sites with similar soils, hydrology, sunlight, aspect, wind exposure, elevation, and slope will result in better performance of plant material at the restoration site.

Moving woody plants larger than 3 feet in height is difficult. Larger trees and shrubs have extensive root systems that cannot be retained when moved and obtaining enough root mass and soil to transplant a large tree or shrub often results in the destruction of the donor site vegetation. Root pruning the selected plant material 12 months before digging can increase transplant survivability by creating a more compact branching root system. Trees larger than 1 inch caliper may weigh over 160 pounds and require a mechanical tree spade to move. Root balls size recommendations are larger for wild grown trees than nursery grown. Table 4c provides the approved minimum root ball dimension for a sample of caliper sizes for moving wild collected deciduous broadleaf trees. This table can be applied to most upright broadleaf deciduous trees, capable of reaching large sizes, such as oaks, sugar maple, hickory species and black cherry. For other types of woody plants (small trees, shrubs, coniferous evergreens), refer to the ANLA American Standard for Nursery Stock website.

Tree and Shrub Plants for Conservation Plantings

Trees and shrubs are used for: (1) riparian buffers; (2) wildlife habitat improvement; (3) pollinator enhancement; (4) agroforestry including biomass and timber production; and (5) windbreaks for erosion control, odor abatement (Figure 4m), energy conservation, living snow fence, screening, and noise abatement.

Table 4c. Caliper/height/root spread relationship for wild collected deciduous broadleaf trees

Caliper (inches)	Average height range (feet)	Minimum root ball diameter (inches)	Minimum root ball depth (inches)
1/2	4 to 5	14	10
3/4	6 to 8	16	12
1.0	8 to 10	18	14
1 1/4	8 to 10	20	14
1 1/2	10 to 12	22	15
1 3/4	10 to 12	24	16
2.0	12 to 14	28	19
2 1/2	12 to 14	32	19
3	14 to 16	38	23

Trees and shrubs can be planted in conjunction with other critical area treatments to provide diversity, cover, and eventual seed sources for areas returning to natural cover. A list of trees and shrubs and their characteristics and requirements is provided in Appendices 2k and 2l. Select species represented in similar nearby ecological communities when planning a riparian revegetation or other restoration project. The restoration or critical area site may be variable due to disturbances that have altered the soils and hydrology of the site. Planting a variety of species, including pioneer species, allows the site to undergo natural succession. Plant diversity is important for: (1) enhancing wildlife diversity; (2) providing specific plants to fit variable microtopography; (3) limiting the encroachment of invasive species; and (4) preventing dominance by a limited number of species planted. Planners should recommend a wide variety of species that are suited to the site and commercially available and require the use of some minimum number of these species for the site. A maximum and minimum number of the selected species should also be specified. Consider these factors when deciding the percentage of each species for a site: (1) function within the plant community (i.e., overstory, understory, shrub); (2) dominance in the plant community; (3) growth characteristics (fast, slow, shade tolerant); and (4) compatibility with other species. When selecting plant species to be planted along streambanks or associated with flood plains consider the selected plants': (1) resistance to stream flows; (2) impact upon hydraulic conveyance; (3) ability to meet erosion control requirements; and (4) impact on fish and wildlife habitat.

Factors for successful installation of woody plants:

- Understand the soil and climate limitations including microclimates and match the species correctly.
- Know the origin of the planting stock, not just the source.
- Provide effective site preparation to increase survival and initial growth, if possible start the fall prior to planting.
- Buy quality stock with good root systems.
- Transport, store, and plant properly.

Figure 4m. Trees and shrubs can be use for windbreaks around livestock facilities for odor abatement and screens.

- Provide protection from predation, for example deer, rabbits, mice or beaver.
- Monitor water needs and irrigate if necessary.
- Follow-up maintenance is mandatory for trees to outgrow competition from other plants and be protected from predation.

Site Preparation and Weed Control for Trees and Shrubs

Site preparation and weed control depends on the previous land use and management and may require starting a year before planting. The species and size of the plant materials to be used and the anticipated level of management may also effect planning for site preparation and weed control. Previously cropped fields where perennial vegetation is absent require minimal initial site preparation. Areas where the sod has been intensely managed or was in a crop rotation will require less site preparation than old hay fields, pastures, idled farm lands and riparian areas that have had little management. It is crucial to control and eliminate all invasive species from conservation planting sites prior to planting to minimize spread.

Prepare the site through mechanical and/or herbicide treatment. Fabric weed barriers (tree mats) and mulch can control weeds when properly installed and maintained. Studies have compared the use of fabric weed barriers and herbicides alone or with tree tubes in controlling weeds. The results vary depending on site conditions, species and planting stock. Fabric weed barriers provide cover for rodents that may girdle the planted trees. Rodents may also build nests in tree tubes. Mowing or herbicide spraying around the weed barrier or tubes will inhibit rodents in the area from nesting in tubes and under mats. The reinsertion of tubes or rodent guards into the soil in late fall and early spring will reduce rodent damage. Weed barriers and tree tubes require yearly maintenance to be successful. When the use of herbicides are not an option nor desired the use of mechanical cultivation, mulching and mowing when used together can be successful.

Mechanical Treatment

Mechanical site preparation provides initial control of weed competition. Disking will often remove broadleaf weeds but plowing and disking may be necessary to retard grasses. Follow-up weed control may be needed during and/or after the first growing season to adequately control weeds. Rhizomatous weed species will be spread by tillage if not preceded by herbicide application. Mechanical site preparation can be done in the fall prior to spring planting. On highly erodible sites, mechanical site preparation should be done in the spring prior to planting, or if conducted the previous fall a cover crop should be planted. Site preparation can be done to the entire field, where risk of soil erosion is minimal and removal of existing vegetation is warranted, but it is preferable to use less tillage. Examples include 3-foot wide strips centered on the planting rows, or in 3 x 3-foot square or 3-foot diameter spots centered on individual tree planting sites.

Herbicide Treatment for Planting Trees and Shrubs

Herbicide treatment will provide initial control of weed competition but repeated herbicide applications or other control methods such as weed barriers will be needed adjacent to the trees to provide adequate weed control for three or more years after planting. Herbicide treatments can be spot or band applied a minimum of 3 feet around the individual tree/shrub planting site. An entire field may be treated if the existing weed types warrant and if a permanent noncompetitive grass seeding is planned. When follow-up spraying is conducted assure that the herbicide will not injure the tree or shrub. All herbicide usage must follow the manufacturer's labeling and state pesticide regulations for the state in which the product will be applied.

In areas with dense vegetative cover, treat with herbicides in late summer or early fall prior to the planting year. This practice will provide optimum weed control and better tree/shrub survival. An assessment of the weed re-growth should be made in the spring prior to planting, with additional herbicide applied if needed.

Fabric Weed Barriers

Fabric weed barriers (tree mats) come as: (1) porous woven polypropylene; (2) a porous polyethylene that allows water to penetrate through micro funnels but restricts evaporation; and (3) UV protected non porous polyethylene. Tree mats are installed as 3 x 3 foot squares or larger around individual plants or as long rolls covering an entire row. Prior to installing weed mats the area should either be sprayed, scalped to remove sod, or mowed to within 1/2 inch and residue removed. The tree is planted and a tree tube (when used) is inserted

into the ground 2 to 3 inches and staked, then the mat is placed over the tube and stake. Install staples to hold the mats in place. Place staples through double folded corners with 5 to 9 staples per mat with at least one staple for each of the 4 corners and one by the tree. It is important to properly staple due to wind and to hinder rodent encroachment. Spraying or mowing around the mats and the use of rodent guards reduces rodent damage.

Mulch

Mulch is organic or inorganic material typically woodchips or bark spread around individual seedlings or larger plants to retain soil moisture, moderate soil temperature, and prevent weed growth. Mulch improves conditions for initial root development during establishment. Scalp sod or mow prior to mulching. Apply mulch in a 3-foot diameter circle around each seedling, 2 to 3 inches deep, and pull back from the plant stem slightly. When applied in this amount there usually is no problem with heat buildup generated by fresh woodchips. Straw or similar mulch material should be avoided as it encourages mice and other small herbivores that may damage the seedlings. Do not mix wood chips into the soil as bacteria decaying organic matter temporarily deplete the soil of nitrogen.

Companion Covers

Permanent sod strips may be needed between tree/shrub rows on highly erosive sites in order to prevent erosion. Permanent companion covers are also used to minimize the risk of more aggressive or invasive vegetation. Refer to Appendices 4c and 4d, for appropriate seed mixes. These mixes usually consist of species which are less competitive to the trees and require less maintenance compared with forage species and varieties.

Tree and Shrub Plant Material Requirements

A discussion of purchasing and descriptions of different planting stock was covered in Chapter 3. All bare root seedling trees and shrubs should have developed root systems and be free of insects and diseases as well as mechanical injuries. All conifers should have dormant buds and secondary needles. Tops or roots should not be trimmed prior to sale unless specified by grower or requested by purchaser. Container-grown nursery stock should be healthy, vigorous with a well-established root system reaching the sides of the container to maintain a firm ball when the container is removed, but should not have excessive root growth encircling the inside of the container. If the plants are slightly pot-bound, carefully tease the fine roots away from the tight mass and spread the roots prior to planting. Plants with extremely woody compacted roots should be rejected. For specifications use the American Standard for Nursery Stock available on the American Landscape and Nursery Association website.

Care of Bare Root Seedlings

Proper care of seedlings prior to and during planting is critical to the successful establishment of plant material. Seedlings with roots that are dried, frozen, or subjected to mold or high temperature are not suitable for planting. Seedlings should be packed and shipped in wet moss or other water-holding medium and after arrival should be kept moist and cool prior to planting. Trees held in the upper 40s˚F or higher for even a week may begin to develop storage mold or root diseases. Therefore it is important to plan for cold storage (ideal temperature between 33 and 37˚F) in case the planting is delayed. If a cooler is not available, keep in a cool moist location, mist with water when needed to keep moist and plant within 7 days. Do not stack tree bundles more than two deep to allow adequate air circulation and prevent overheating. For longer storage heel in the seedlings in a shaded area and keep them moist. To heel in seedlings, dig a trench in well-drained soil, place the seedlings in the trench and cover the roots with soil then mulch and wet the soil and roots during the process. The addition of well-rotted compost and woodchips can aerate the soil and make lifting roots easier. Resume normal tree planting as soon as suitable conditions exist.

Exposure to sun and wind can kill seedlings in less than 30 seconds. Use moist burlap, cloth, sphagnum moss, or other packing material to cover seedlings when in the field. Do not keep seedlings in a bucket of water for more than 1 to 2 hours, instead mist seedlings or dip covering material in water to keep moist. A fine-grade water absorbent/retention (hydrogel) dip will conserve moisture on seedling roots during the planting process and should be considered when planting in dry weather and on dry sites. Follow the manufacturer's label when using hydrogel, it is important that the hydrogel be fully hydrated or else it may extract water from plant roots.

Planting and Spacing Requirements

Tree and shrub spacing and densities vary depending on the species, purpose of the planting, expected mortality, soils, site preparation, maintenance requirements and herbivory. The size of the planting stock and degree of tree and shrub protection will influence survivability. Spacing and arrangement is a balance between aesthetics, natural appearance, and maintenance needs. Offsetting in rows provides a random appearance while allowing for easy access and maintenance. High-density plantings improve stem form and value while reducing the need for long-term weed control due to quicker canopy closure. For conservation and wildlife plantings consider grouping trees and developing corridors to achieve densities.

Tree and shrub plant spacing is based on purpose of planting:

- Timber production; Conifers - 600 to 1000/acre; Hardwoods - 545 to 900/acre;
- Wildlife Plantings- 302 to 1200/acre; certain wildlife plantings may require densities outside this range;
- Christmas Trees- 1200/acre;
- For critical area and erosion protection and for generic windbreaks- plant small shrubs 3 to 6 feet apart, large shrubs 5 to 8 feet apart, evergreens 6 to10 feet apart and deciduous trees 8 to12 feet apart. Multiple rows are usually used for windbreaks.

When spacing is adjusted, consider the mature height and width of the species, the growth characteristics of the species such as thicket and grove forming species and competition between species. Densely spaced shrubs may be used for quicker erosion control and weed suppression providing early canopy closure with a thinning conducted later as the shrubs fill in.

To determine trees per acre from plant spacing use the following formula.

Plants per acre= 43,560 ft^2/ac ÷ (spacing between plants within rows) x (spacing between rows). The orientation does not have to be in rows.

For example, if the plant spacing is 6 feet x 6 feet, 1210 trees are required per acre, 43,560ft^2/ac ÷ 36 ft^2= 1210 trees/ac.

Tree and Shrub Planting Requirements

Trees and shrubs should be planted in the spring soon after the soil thaws and before their buds open. Fall planting is acceptable for deciduous trees and shrubs, except on soils where frost heaving is a serious problem or on extremely droughty soils. Fall planting should take place soon after leaf drop, providing time for new water absorbing roots to develop before the soil freezes. In general, fall planting of conifers has been significantly less successful than spring planting. This is true especially when they are planted late and roots do not get established leading to desiccation over the winter. If planting conifers in the fall, plant as early as possible and protect them from drying wind. If antidessicant is used apply only on the sides exposed to the sun and wind. Whenever possible, plant conifers during the early spring planting season. Do not plant any trees and shrubs in late spring or summer unless mulch and irrigation will be provided. Do not assume anti-transpirants (anti-desiccants) will always provide adequate protection, their effectiveness depends on the material, timing, plant species, and environmental conditions. In some instances some products will inhibit photosynthesis by blocking carbon dioxide uptake through the stomates, if used, they should be applied conservatively at low dosages to only some of the leaves on a plant. Planting dates for different planting stock is provided in Appendix 4a. Plant trees in the middle of the prepared site or area to ensure maximum distance from competing vegetation.

Nitrogen fertilizer is not recommended during the establishment year especially for fall plantings. Fertilizing in the spring during the establishment year may promote excessive top growth without supporting root development. This may lead to abnormal growth or mortality. If fertilizer is applied use a slow release balanced fertilizer blend.

Water all planting stock before planting, during the planting process, and throughout the first growing season. For large trees weekly watering will be necessary. Water throughout the first growing season when weekly precipitation is less than 1 inch. The use of 20 gallon watering bags or a 5 gallon bucket with appropriate number of small holes to deliver a slow release of water is helpful.

Bare Root and Small Containerized Seedlings

Tree and shrub seedlings may be planted with a tree planting machine or by hand using a planting bar,

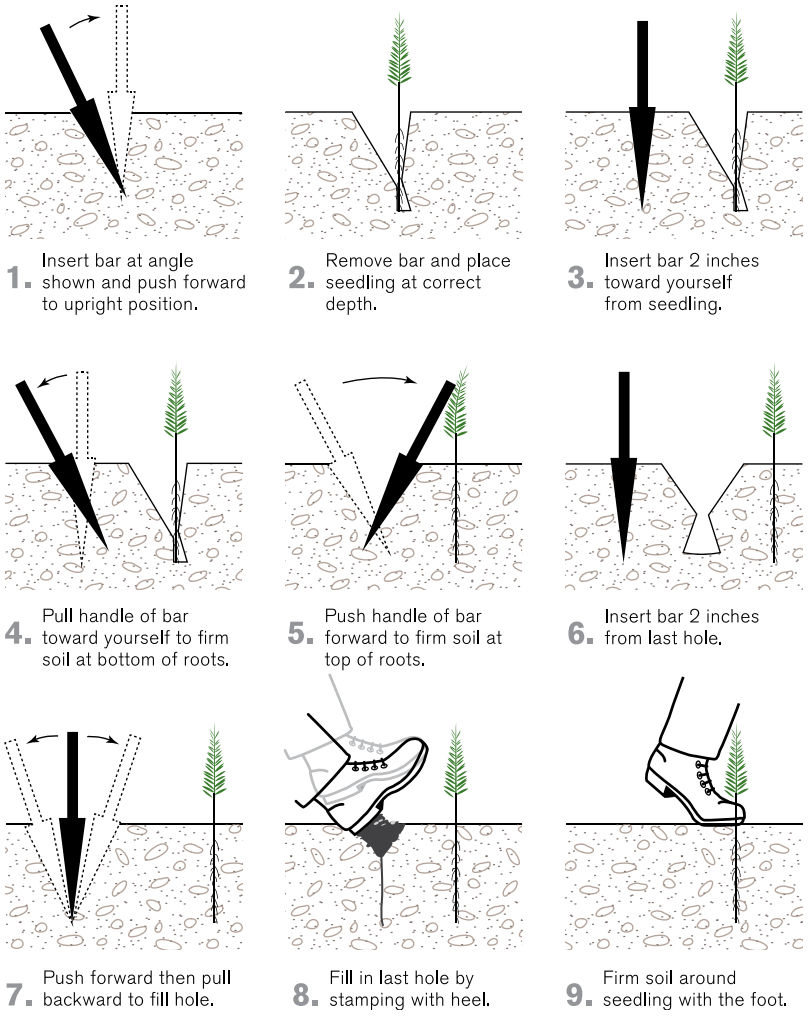


Figure 4n. Planting bar technique for planting bare root seedlings. (USDA Forest Service)

mattock, shovel, or spade. The planting bar is usually the faster method but the other tools can produce a larger hole to accommodate longer roots. Refer to Figure 4n, for an illustration on how to use a planting bar to plant bare root seedlings. Plant tree and shrub seedlings vertically with the root collars equal to or up to one inch below the soil surface ensuring adequate coverage of the roots with soil. When planting bare root seedlings, vertical roots must fit the planting hole and should either be pruned to a length of no less than 8 inches, or preferably, a hole dug deep enough to accommodate the roots. The trench or hole should be deep and wide enough to permit the roots to be spread out in a natural, uncurled position. Avoid "J" rooting (Refer to Figure 4o, drawings 1, 2, and 3). Firmly pack soil around the seedlings to eliminate air pockets and supply supplemental watering to increase survival during droughty periods. When planting large bare root trees, dig the hole 2 to 3 times wider in all directions than the root spread. Plant the tree so that the beginning of the root flare is visible at soil level. It is critical not to plant the tree too deep. Mulch over the entire rooting area with 2 to 4 inches of wood chips or shredded bark mulch. Stake and use tree shelters where needed. Weekly supplemental watering is mandatory with large bare root trees,

The use of augers is becoming more popular with commercial tree planting companies for planting small containerized plants. When an auger is used, make sure the auger is at least twice the diameter of the container and do not drill deeper than is needed since trees often settle too deep. To allow for proper drainage and root penetration, loosen the sides of the hole especially if the hole becomes glazed typical of clay soils. Some hand held augers are not as efficient as hand planting.

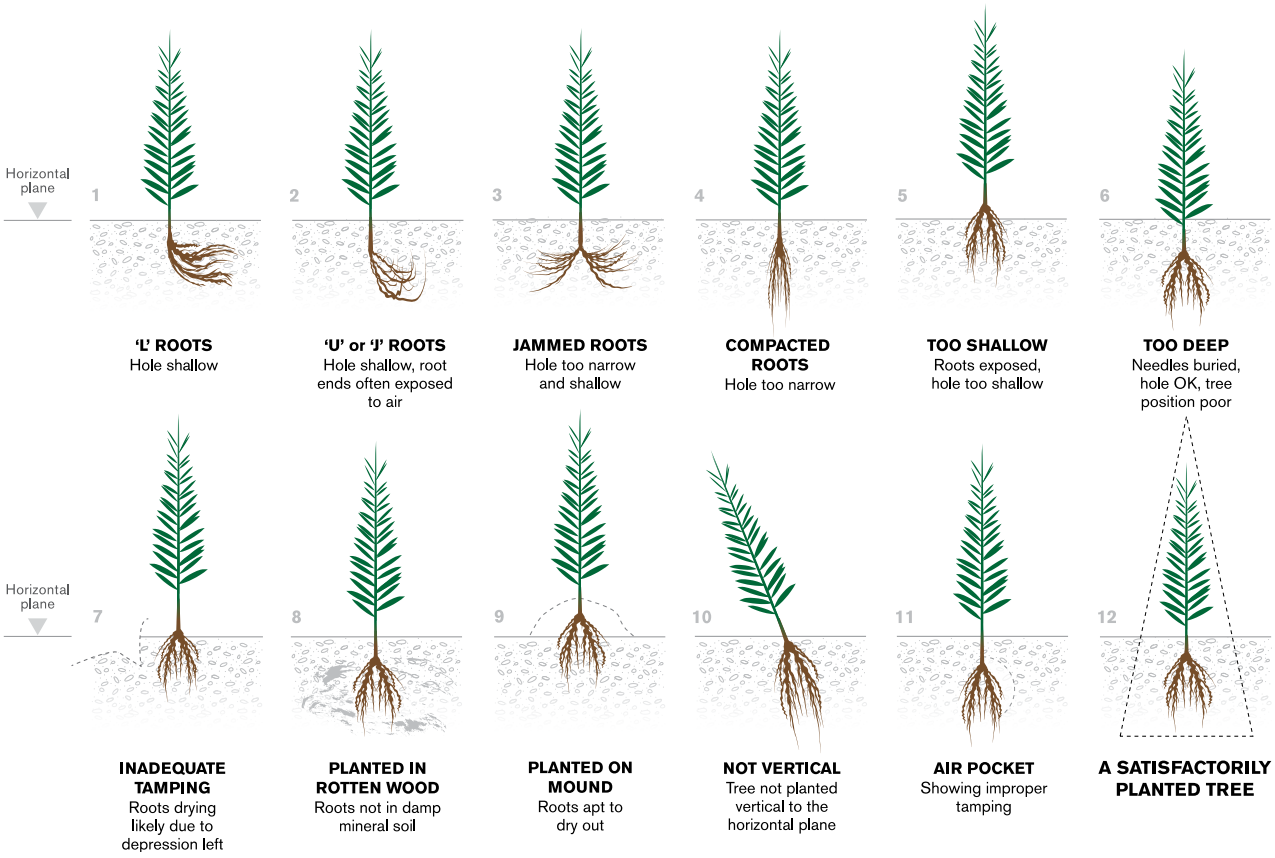


Fig. 4o. Illustrates mistakes to be avoided when planting bare root seedlings. (Adapted from US Forest Service).

Regardless of the planting method used, trees should not be planted in overly wet soils. Planting in dry soils should also be avoided unless trees will be watered immediately after planting. In sandy soils, planting containerized plants with a peat-based growing medium augmented with super absorbent polymers can improve seedling survival.

Balled and Burlap and Large Containerized Stock

For balled and burlap planting (Figure 4p) dig a hole 2 to 3 times wider and at the depth of or slightly shallower than the root ball and roughen the sides and bottom of the hole allowing the roots to penetrate the soil. Remove all twine or wires and open or pull back the top of the burlap. Be sure to completely remove plastic liners or synthetic burlap materials. Backfill soil around the tree to the height of the root ball, but leave the top of the root ball (where the roots end and the trunk begins) 1/2 to 1 inch above the surrounding soil making sure not to cover it unless roots are exposed. When back filling firm soil enough to prevent air pockets, but do not over compact. Over-compaction will prevent water from reaching the roots and the roots from expanding beyond the ball. Form a temporary water basin around the base of the tree to encourage water penetration, and water thoroughly after planting. Water throughout the first growing season when weekly precipitation is less than 1 inch. Large trees may require staking for a few years. For large containerized plants remove the plant from its container and treat roots as mentioned in the previous containerized plant section. Dig hole to same depth as container and 2 to 3 times as wide and make sure the potting soil is covered on the surface with the native soil. Back fill as previously discussed as with ball and burlap, avoiding compaction.

Tree Tubes and Shelters

Tree tubes are preformed plastic tubes manufactured in different colors, levels of translucence, and with and without vents. Tree shelters are plastic sheets that are assembled/rolled on site and installed around tree seedlings. The shelters are vented by way of their construction and can be doubled for larger capacity. Individual tree or area fencing

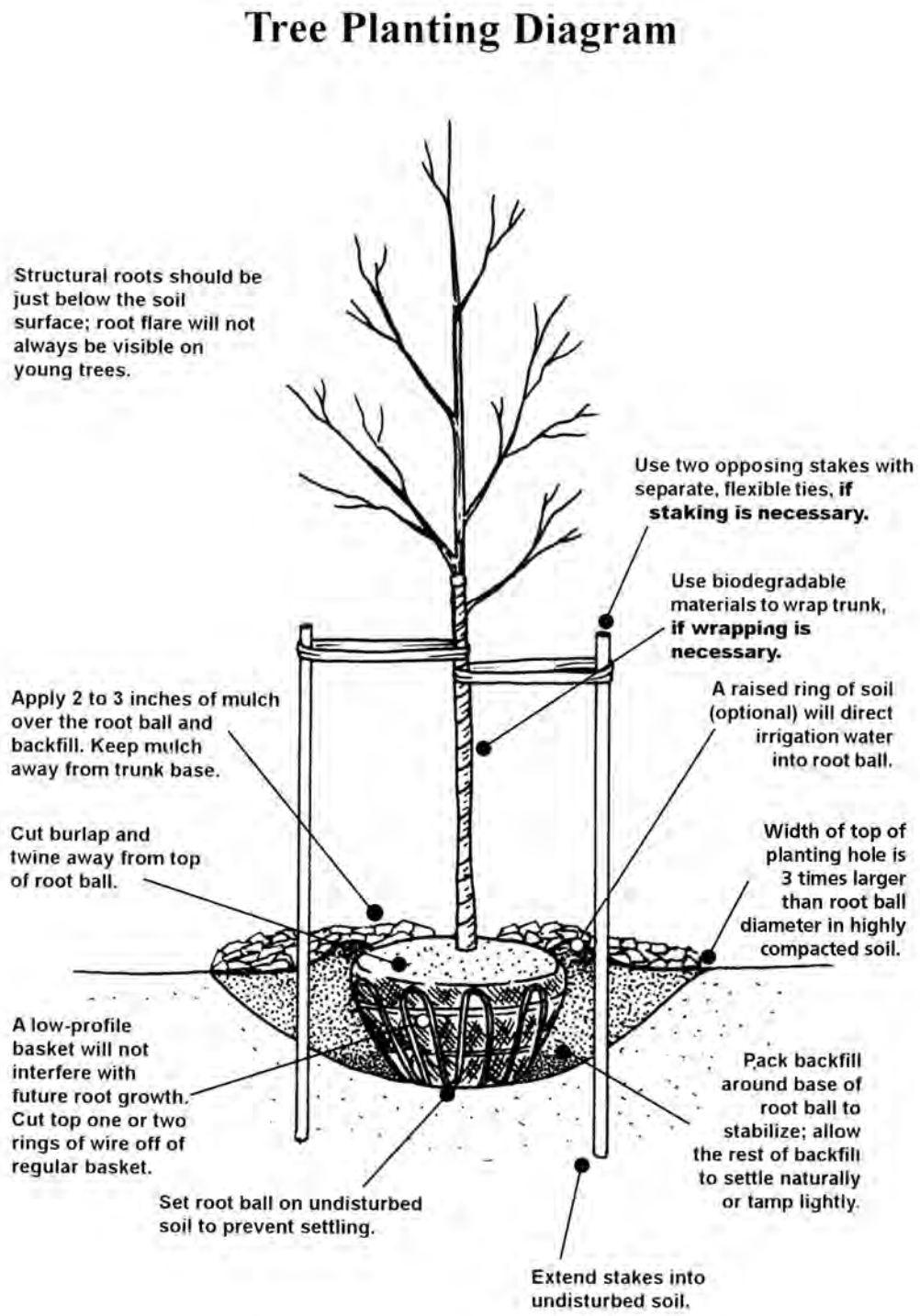


Figure 4p. Proper method to plant large Ball and Burlap stock.

is an option as well. The tree tubes should contain vents and be translucent to prevent excessive heat and moisture buildup. These features allow seedlings to enter and break dormancy naturally. Seedlings grown in translucent tubes with ventilation have better diameter growth since they are not stretching toward the light. Tubes are generally 3.5 to 4 inches wide although, larger diameter types are available. To secure tubes or shelters place 4- to 5-foot tall hardwood stakes 8 inches into the ground on the windward side of the planting site, before the tree is planted. After planting place a tube over the tree, insert the tube two inches into the ground, and attach tube to the stake with two fasteners, then install mat. Netting is sometimes installed over the tubes to protect birds (bluebirds) from getting stuck and to prevent wasps from nesting. Remove netting just prior to seedling emergence to prevent damage to seedling.

Maintenance

Control competing vegetation during the first three years by cultivating, mulching, using fabric weed barriers, and/or herbicide treatment. Good weed control significantly increases the chances for successful tree establishment. Note that care must be taken to prevent damage to tree and shrub during cultivation, spraying or mowing.

Mowing is not considered a weed control practice in field plantings as it tends to stimulate root growth of grasses and it reduces the potential for natural regeneration. It can be useful between tree rows to improve access or around individual trees to reduce cover for potentially damaging herbivores and rodents.

Exclude livestock and deer from all plantings and monitor to protect from insect, disease, and animal pests by use of shelters, wire guards, repellents, pesticides, or fencing as needed. Shelters and rodent guards should be set into the ground to a depth of 2 inches. In areas with heavy deer pressure, protect all hardwood seedlings to a height of 5 feet. Trees also need to be protected from buck rubbing even after trees are larger than 5 feet. Keep the tubes on until the trees outgrow the tube diameter to prevent buck rubbing. Stakes, tree tubes, rodent guards, and mats need to be periodically maintained and reset due to frost heaving and wind. This will prevent damage to the seedling from the tube falling over or from rodent encroachment. Mow or spray around trees or mats to reduce cover for the first three years. When the slope is moderate, woodchips or bark can be used as an alternative to mats, however woodchips may need to be replenished.

Deer repellents are best for small orchards, gardens, and ornamental plantings around the home. Their utility is limited for other large acreages because of high costs, limitations on use, and variable results. When used, apply repellents at the first sign of damage or before to prevent deer from establishing a feeding pattern. The effectiveness of repellents depends on the number of deer, their feeding habits, and environmental conditions. If deer are very hungry and other food supplies are limited, repellents may not work. University research trials have shown that fear-inducing sulfur odor-based products containing decaying animal protein such as eggs or slaughterhouse waste usually outperform taste-based materials. No commercial repellent is 100 percent effective, and under heavy deer browsing pressure the best materials must be reapplied about every five weeks, especially on new growth.

Soil Bioengineering

Soil bioengineering focuses on the use of layers or bundles of woody plant materials to stabilize soil. Steep slopes such as road sides and other upland construction sites may benefit from soil bioengineering techniques. Streambanks and small lakes where impacts from water flow and wave action cause erosion problems are primary examples of potential sites to utilize soil bioengineering. In the case of streambank stabilization, stream restoration structures like J-hooks, vanes, and weirs, which divert water away from the streambanks and stone for toe stabilization, may be needed to increase the effectiveness of soil bioengineering techniques. Many sites require some earthwork before soil bioengineering systems are installed. A steep undercut or slumping bank, for example, may require grading to a 2:1 or flatter slope. Soil bioengineering alone or in combination with engineered structures reduces the force of water against a stream bank or shoreline and also increases the bank's resistance to erosive forces. Soil bioengineering places woody plant material into specified configurations in the soil. These configurations provide immediate soil protection, reinforcement, and improve slope stability.

Soil bioengineering uses woody plant materials, typically easy-to-root shrub species, cut when dormant and placed prior to rooting into configurations which provide some immediate stability. As roots form below ground and shoots form above ground the slope becomes resistant to erosion and failure. Slope stability is enhanced by the shear strength and tensile strength of the extensive

root mass that is produced, by the surface cover provided by stems and leaves and to a limited extent by the removal of excess water from the soil profile. Roots produced by soil bioengineering applications become continuous across the slope, as opposed to the discontinuous roots of cuttings and stakes installed on a grid pattern. Soil bioengineering assists in stabilizing streambanks by trapping sediment, reducing velocity, reducing stresses acting on the bank and redirecting flows. These practices are most effective on streambanks within relatively stable systems. Rehabilitation of highly degraded systems requires substantial investment of resources and may be so disturbed that partial success is often the only realistic goal. Grass seeding at a reduced rate, used in combination with the woody plant materials provides a quick soil cover and additional root mass. Effective and permanent exclusion of livestock is mandatory for successful use of soil bioengineering techniques.

Some key factors in evaluating sites for bioengineering potential are:

- Causes and extent of erosion problems
- Channel slope
- Stream classification
- Soils
- Magnitude and frequency of flow events
- Water velocity
- Stream bank position
- Bank hydrology
- Ice flow in spring
- Bank slope percentage and length
- Fetch distance and wind direction on large expanses of water
- Sunlight
- Existing vegetation
- Damage hazard

As slope stability is achieved by the growing vegetation, other factors improve as well such as organic matter and moisture holding capacity of the soil. Native (local) vegetation will begin to volunteer and blend the site into the surrounding landscape. The species used for soil bioengineering are mostly pioneer or early successional species and will be dominated by the indigenous climax species over time; this transition period can be reduced by planting climax species as part of the installation. Climax species should be planted above the zones subject to high velocity flows.

The use of soil bioengineering techniques along with other associated plantings increases other ecosystem functions. These techniques restore the physical, biological, and chemical functions and values of streams, streambanks or shorelines; improve water quality through reduction of temperature and chronic sedimentation problems; and provide opportunities to connect fragmented riparian areas.

Plant Materials for Soil Bioengineering

The plant materials used are usually from shrub species with somewhat flexible stems, having the ability to root from stem tissue (adventitious roots) and are easy to root as dormant hardwood cuttings. These materials exhibit coppice growth, the tendency of certain woody plants to produce many new shoots when the main stems are harvested and the root systems are undisturbed. The material is harvested when dormant, and planted immediately or held in a dormant state preferably in a cooler. Refer to Appendix 3c for a list of species in the Northeast suitable for soil bioengineering and some of their characteristics useful for planning. Willows have several different growth forms, from shrubs to large trees. Small to medium-sized shrub-type and rhizomatous or creeping-type willows are used when planting channel banks. Some upland willow species are found in relatively dry areas such as prairie willow (*Salix humilis*) and should be used on similar sites or avoided since they are typically more difficult to root. Many lowland willows can be grown on upland soils if not classified as excessively well-drained. Tree-type willows and other riparian tree species are selected for the flood plain area. Trees should be planted away from high-velocity flows to avoid future undermining and damage to streambanks. Red osier dogwood and common elderberry tolerate shade and can be used in more shaded conditions. Soil bioengineering techniques are accompanied by seeding for added erosion control.

Plans for acquiring plants either from nurseries or wild sources must be made well in advance of project implementation. Planting stock from nurseries may perform better than older material cut from the wild. Their culture in the nursery allows for rapidly growing, tall, straight stems which are easier to handle and may root better. Native stands may be subject to stresses which will impact performance of cut materials. Some of the factors discussed earlier in this chapter concerning digging wild

plants, "moving wild plants from donor sites" also apply to vegetatively cut material. Additional information on purchasing soil bioengineering material and cutting from wild sources is covered in Chapter 3.

Use harvesting equipment that is sharp enough to make clean cuts and cut material to a height of 4 to 6 inches. For most species, this will rejuvenate the plant so usually the entire plant is harvested. The materials used in soil bioengineering can be harvested in late winter through early spring. In the spring, the branches should be harvested before the flower or leaf buds have broken. Survival decreases if harvested and planted in a non-dormant state especially since that time of year may be more stressful due to the potential for warmer and drier conditions and may require irrigation. Plant the material in the early spring when soil moisture conditions are favorable for rooting but after the major spring runoff to avoid being washed out. Less than 1- year-old wood or suckers will often sprout, but often do not have enough stored energy for good root establishment. Stems 2 to 5 years old with smooth bark have the vegetative reserves (energy) necessary to consistently root and sprout. Avoid older material which is deeply furrowed. It is beneficial to soak cuttings from 1 to 7 days prior to planting to initiate root growth within the inner layer of bark. When planting, use recently excavated moist soil, tamped firmly to eliminate voids thereby obtaining close contact between plant material and soils.

Handling and Storing Plant Materials for Soil Bioengineering

Tightly bundled materials of uniform lengths are easier to store, transport, and handle than loose bundles. Refrigerated coolers are best for long-term storage and plants should be stored at 33 to 37°F or colder (light freezing is fine) with the bark remaining wet or encased in ice with continuously high (close to 100 percent) relative humidity. Plant material can be held until June 1st under these conditions. Cold, dry storage, on the other hand, will freeze-dry the materials and is not acceptable. Without refrigeration on site, the materials should be installed within 2 to 4 days depending on weather conditions. Materials can be stored outside for relatively short periods if the materials can be kept cold, damp, or wet and in full shade.

Exposure to sun and wind has to be avoided. When storing outside use tarps, north sides of buildings, packing in snow, or under dense evergreens. Materials can also be submerged in a pond or stream pool for short periods. However if stored too long the material will start to root. When cuttings or stakes are stored in containers with water, change water periodically. Materials that are not in good dormant condition should be planted within 24 hours of arrival. Maintain plant materials cool, moist, free from wind desiccation, and shaded when transporting between the nursery or collection site and until planted at the project site.

Construction Material

Construction stakes, used to secure the soil bioengineering material to the soil, are usually made out of two by fours cut diagonally across the 4-inch face, and are 2 to 3 feet long depending on the application. To secure the plant material to the stakes use smooth No. 16 wire or machine spun bristle coir, thickness 0.2 to 0.25 inch with breaking strength of 70 to100 pounds. Biodegradable baling twine can be used on smaller applications for tying wattles. Live stakes are sometimes recommended for support but there are survival problems with excessive handling of the live stakes in this manner so the material is best utilized independently adjacent to the soil bioengineering technique.

Timing of Stream Projects

Streambank plantings should occur as soon as possible after the spring runoff has subsided and while the plant material is still dormant. This gives the vegetation time to establish before exposure to the stress of summer and the following year's spring runoff events. Fall plantings can be used, although performance will be inferior since the materials will not be well established in the spring and may not withstand damage from the following spring's runoff events. Upland stabilization projects are best planted in the late fall at the onset of plant dormancy, in the winter as long as the ground is not frozen, or in early spring before growth begins.

Soil Bioengineering Technique Descriptions

There are many techniques used in soil bioengineering and there are many resources listed in the reference section as well as below to get complete information. Described below is basic information on planting cuttings, live stakes, and willow fascines. Other techniques typically used are brush layering, branch packing, brush mattress, vegetated

geogrids, live crib-walls, joint planting, and others. They require more equipment, material, and cost but will withstand higher velocities and shear stress than the live stakes and fascines. The variety of soil bioengineering techniques are increasing thanks to the ingenuity of practitioners and the availability of new plant materials and manufactured products that are being developed.

For complete information on planning and design specifications for soil bioengineering techniques refer to USDA-NRCS National Engineering Field Handbook. Chapter 16 "Streambank and Shoreline Protection" and Chapter 18 "Soil Bioengineering for Upland Slope Protection and Erosion Reduction". Also refer to the multiagency Stream Corridor Restoration Handbook.

Cuttings and Live Stakes

Small cuttings 1/4 to 1/2 inches in diameter and 10 to 14 inches long are used in nursery production to produce rooted cuttings or used directly for erosion control in favorable conditions. Live stakes are stem cuttings of dormant willow or other adventitiously rooting species that are 1/2 to 2 inches in diameter and 1.5 to 3 feet in length. Larger diameter material cut from relatively young stems is also acceptable. Cuttings and stakes are made with sharp shears or machete and bundled to maintain proper orientation. Painting the tops with latex paint can facilitate identifying the end and reduces drying. Cutting at a 45 degree angle on the end toward the trunk (the bottom of the cutting) will facilitate driving as well as identifying the ends. Prepare stakes no longer than 1 week before planting unless they are to be placed in cold storage (33 to 37°F) with close to 100 percent relative humidity. On dry sites stakes are often not successful unless fall planted. Stakes are often planted on a grid system 1.5 to 3 feet apart using triangular spacing or spaced randomly 2 to 4 stakes per square yard, some installations include an erosion control fabric. Stakes should be inserted in the ground a minimum of 8 to10 inches up to 4/5 of the length to reach soil moisture for successful rooting and to ensure that at least 2 nodes are buried. In some situations stakes should be long enough so the bottom of the stake will reach to the depth of moist soil during mid-summer. Stakes should be pushed into soft ground oriented with the buds pointed up, perpendicular to the slope and slightly downstream. In hard ground, stakes should be planted into pre-prepared holes using a planting bar or iron rebar to avoid damaging the bark of the stakes. A rubber dead blow mallet is recommended for driving stakes. Insert the stakes in the ground to within 2 to 6 inches of the tops or cut tops leaving no more than 6 inches exposed. Tamp firmly around the stakes when possible to provide a firm hold, and to prevent air pockets around the stakes. For dry sites irrigating the cuttings or stakes can assist with removing air pockets.

Live staking for streambank stabilization is more successful when used in conjunction with other techniques, since the individual root systems are not as intertwined as other soil bioengineering techniques. One advantage of live stakes is that they can be inserted without digging or bank shaping where applicable or to augment a site with existing vegetation. Live stakes can also be used in situations where other techniques may not be practical or possible, such as to insert into pre-existing riprap (rocks). When planting into riprap, use long stakes at least 1/2 inch in diameter and at least 2 feet long, as the longer, thicker stakes will survive heating and drying better than smaller diameter cuttings. Cut excess, exposed portion of the stake to avoid desiccation. The stakes generate a cover for the stone, improving the aesthetics, and also create shade for the stream to reduce the thermal transfer from rocks to the water. When retrofitting an existing riprap site, a steel bar is used to wedge the rocks apart so that the live stake can be inserted into the soil below. Some riprap is too heavy and in layers too thick for this to be practical. In moderately shaded conditions, use longer stakes and leave 1 foot sticking above the ground. Avoid densely shaded areas.

Rooted Cuttings

Rooted cuttings are produced by placing dormant cuttings in a rooting bed for a growing season. They are then dug when dormant and held in cold storage until shipped to the field planting location. They are planted, as previously discussed in this chapter, like bare-root seedlings in the spring, with appropriate care to avoid damage to the roots. Rooted cuttings and seedlings can also be used to increase species diversity by using species that can only be reliably propagated in a nursery system.

Live Fascines or Wattles

Live fascines, or wattles, provide the structure for immediate protection against surface erosion for streambanks or upland sites and can change overland flow by breaking up long slopes. The live fascines eventually root and provide

permanent reinforcement. This practice can be used alone on smaller drainage areas or in conjunction with other soil bioengineering techniques and engineered structures on larger watersheds. Often multiple rows are placed across the slope to be protected, working upward from the bottom. The growth that results from this method provides a far faster, denser root mat and much greater above ground stem density than is achieved by planting cuttings or stakes (rooted or unrooted) as discussed above. Using quality plant materials, this technique may have the best general combination of economy, ease of installation, and usefulness on small streams and other banks.

Fascine and Wattle Construction

Live fascines or wattles are made up of 2- to 5-year-old; long, straight live branches from adventitiously rootable material (usually willows). The individual branches sometimes called whips when single stemmed are 3/4 to 2 inches in diameter and 5 to10 feet long (Figure 4q). Stagger branches in a uniform line 5 to 20 feet long depending on site conditions and handling capabilities and vary their orientation. Prepare in 6- to 8-inch diameter bundles, bound with untreated twine tied tightly in intervals of 1.5 to 2 feet with a minimum of 2 wraps. Bundles should not be prepared more than 2 days in advance without adequate storage provisions. They may be prepared up to 7 days in advance of placement if provisions are made for storing the bundles in a cooler or by keeping them in a cool location wetting them often enough to keep them constantly moist, covered, and in the shade. Minimize exposure of the fascine to sun and wind throughout the operation.

Figure 4q. Whips or live dormant branches used for constructing fascines or wattles.

Fascine Installation

The fascines are laid in trenches dug slightly less than the diameter of the bundles. On dry slopes dig the trench along the contour or on wetter slopes to facilitate drainage install at a slight grade. Start installation at the base of the slope above bank full discharge except on very small drainage area sites (generally less than 2,000 acres) where it may start lower on the bank. For some applications erosion control fabric is placed in and between the trenches to increase stability. The fascines are secured by construction stakes directly through the fascine every 2 to 3 feet, flush with the top of the fascines. The bundles should overlap 1 foot and be staked at this juncture. Cover the bundles immediately with moist soil and work or wash in to provide good soil to stem contact. The stems are covered with no more than 1 inch of soil with some of the stems remaining exposed to sunlight to promote sprouting. In some applications live stakes are inserted on the downhill side of the fascine every 2 to 3 feet. The configuration and spacing between the trenches on the bank is site specific. In most installations the fascines are planted in lines parallel to the stream, starting at the base flow elevation or just above the riprap (if used) and working up the bank with successive lines. Establish lines no further apart than on 2.5 feet elevation changes. The upstream end of each line should bend up the bank, to reduce stream flow from scouring behind the fascine.

Appendix

Appendices

2a Comparison Chart: Warm Season vs. Cool Season Grasses
2b Plant Data Base Characteristics Legend
2c Non-Native Cool Season Grass Characteristics for Planning Conservation Plantings
2d Native Cool Season Grass and Sedges for Planning Conservation Plantings
2e Native Warm Season Grass Characteristics for Planning Conservation Plantings
2f Warm Season Grass Cultivar Recommendations for the Northeast
2g Introduced Legume Characteristics for Planning Conservation Plantings
2h Native Legume Characteristics for Planning Conservation Plantings
2i Wildflower Plant Characteristics for Planning Pollinator and Conservation Plantings in the Northeast
2j Seeding Rate Calculator for Conservation Practices
2k Tree Characteristics for Planning Conservation Plantings
2l Shrub Characteristics for Planning Conservation Plantings

3a Minimum Germination and Purity Requirements of Certified Seed
3b Planting Equipment Calibration
3c Northeast Shrubs Suitable for Soil Bioengineering Systems

4a Seeding and Planting Dates by Plant Hardiness Zone and Plant Type
4b Temporary Seeding for Site Stabilization
4c Recommended Permanent Seeding Mixtures by Purpose
4d Seed Mixes and Associated Soil Drainage Class and Shade Tolerance
4e Guide to Mulch Materials, Rates, and Uses
4f Mulch Anchoring Guide Specification Sheet

Appendix 2a. Comparison Chart: Warm Season vs. Cool Season Grasses

Topic	Warm Season Grasses	Cool Season Grasses
Erosion Control and Water Quality	Provide long-term benefits for erosion control and sediment trapping. Produce more overall biomass than cool- season grasses. Provide nutrient uptake during the summer when cool-season grasses are dormant.	Provide short-term and long-term benefits for erosion control and sediment trapping. Provide nutrient uptake earlier in the spring and later in the fall than warm-season grasses.
Wildlife Habitat	Provide excellent nesting and feeding habitat. Bunchgrasses provide openings for feeding, while maintaining overhead protection from predators. Stiff-stemmed grasses are more likely to remain standing for good winter protection. Plantings are more likely to remain diverse, supporting a balanced mix of plant species and insect populations.	Due to earlier "green-up," provide a better source of food (green foliage and insects) in early spring than warm season grasses. Tend to mat down more quickly than most warm season grasses as they age. This degrades the quality for nesting, feeding, and overhead protection.
Establishment	Usually need a specialized seed drill to plant these grasses. Seed may be more expensive and less readily available than cool-season grasses. Usually do not need much lime or fertilizer. Tolerates poor soil conditions (i.e., nutrient-poor and/or low pH) better than cool-season grasses. Seeds are slow to germinate Seedlings usually need 2 to 3 years to establish. Can only be seeded in the spring. Weed competition is often a problem during establishment, especially on the better soils. Seedlings and established stands are very drought tolerant. Good for sites with low moisture holding capacity (e.g., gravel mines, rocky slopes,).	Plant with a conventional grass drill or cultipacker seeder. Can sometimes be planted with a grain drill. Relatively inexpensive, readily available seeds. Have higher nutrient requirements than warm-season grasses. Less tolerant of poor soil conditions. May need fertilizer maintenance. Seeds germinate fairly quickly. Seedlings are usually well established 1 to 2 years after planting. Rapid seedling growth results in less weed competition during establishment. Can be seeded in spring or late summer. Can also be seeded with cool season legumes. Higher seedling mortality and thinning of established stands on dry sites or during drought periods, unless supplemental water is applied.
Maintenance	Maintained by using prescribed burning or, mowing to 6 inches tall, with residue removed every 3 to 4 years. Grasses are long-lived and usually do not need reseeding. Can be hayed or grazed with careful management. Selective herbicides may be used for weed control.	Maintained by mowing on a 2- to 3-year rotation, and by overseeding with legumes every 3 to 4 years. As stands mature, grasses may thin out and need to be reseeded. Easier to manage grazing and haying. Selective herbicides may be used for weed control.
Other Issues	Most species grow very tall (5 to 8 feet), and depending on where they are planted, can "block the view." This may be a benefit or a drawback, depending on what is nearby. Fire hazard on overwintered standing grass.	Tend to be low-growing (3 feet tall or less). Some may be invasive or competitive with native flora.

Appendix 2b. PLANTS Data Base Characteristics Legend

Specific plant characteristics have been identified for each of the native and introduced grass and legume species that are recommended. Information from the PLANTS Database was used exclusively in Appendices 2c, d, e, g, and h, which will be linked to the data base in the online version for more information. The PLANTS Database was used as one of the references for the wildflower, tree, and shrub tables. Use the information in those tables to determine site adaptability and species compatibility when selecting or developing seeding mixtures. Refer to the following definitions for specific guidance for each characteristic.

PLANTS Database characteristics have been compiled for over 2,000 species and an additional 500 cultivars from the scientific literature, gray literature, agency documents, and the knowledge of plant specialists. Characteristics data values are best viewed as approximations since they are primarily based on field observations and estimates from the literature, not precise measurements or experiments.

Definitions:

Scientific Name: Genus and species Latin name

Common Name: Name generally used for a specific plant

Growth Habit: Characteristic appearance, form and manner of growth: grass, grass-like, forb, shrub, or tree

Duration: Life cycle: annual, biennial, or perennial

US Native: Species native to the United States, native or introduced

Wetland Indicator Status: Code to indicate plants occurrence in wetlands, refer to "National List of Vascular Plant Species that occur in wetlands," US Fish and Wildlife Service Biological Report 88, US Fish and Wildlife Service, 1988

Active Growth Period: Season when active plant development occurs

Bloom Period: The bloom period is defined as the time when pollen is shed and stigmas are receptive reported by season or indeterminate

Growth Form: Description of plant shoots at or below ground level in relation to soil stabilization: bunch, rhizomatous, stoloniferous, single or multiple stemmed

Foliage Texture: What is the general texture of the plant's foliage: fine, medium, or coarse

Growth Rate: Relative rate of plant development during active growth period: slow, moderate, or rapid

Regrowth after Harvest: Relative rate of plant regrowth after harvesting by grazing or cutting

Bloat: Swollen or inflated reaction to consuming a plant species: none, low, medium, or high

C:N Ratio: Relative amount of carbon to nitrogen in the plant: low, medium, or high

Mature Height: Average plant height at end of growing season

Lifespan: Relative length of productive life: short, moderate, or long

Nitrogen Fixation: Conversion of atmospheric nitrogen by soil microorganisms into usable nitrogen compounds: yes or no

Appendix 2b. PLANTS Data Base Characteristics Legend (continued)

Shape and Orientation: Profile of plant development and growth: prostrate, decumbent, semi-erect, or erect

Toxicity: Presence of toxins: none or slight

Flower Color: Prominent color of the flowers in bloom

Course Textured Soil Species: Adapted to sands or loamy sands: yes or no

Medium Textured Soil Species: Adapted to sandy loams, loam, silt loam, or silts: yes or no

Fine Textured Soil Species: Adapted to sandy clay, silty clay, or clay: yes or no

Anaerobic Tolerance: Relative adaption to wet sites and occasional ponding: none, low, medium, or high

CaCO3 Tolerance: Relative adaption to calcium carbonate in the topsoil: none, low, medium, or high

Moisture Use: Relative requirement for water through the active growth period: low, medium, or high

pH, Minimum: Lowest pH (water) for establishment and productive growth

pH, Maximum: Highest pH (water) for establishment and productive growth

Drought Tolerance: Relative adaption to severe water shortages during active growth period: low, medium, or high

Fertility Requirement: Relative need for nitrogen, phosphorus and potassium: low, medium, or high

Root Depth, Minimum: Minimum soil depth for plant establishment

Salinity Tolerance: Relative adaption to soil soluble salts: none, low, medium, or high

Shade Tolerance: Relative adaption to sites with limited sunlight: intolerant, intermediate, or tolerant

Temperature Minimum: Climate regime for plant survival in degrees Fahrenheit

Vegetative Spread Rate: Relative speed for expanding area of coverage with stolons or rhizomes: none, slow, moderate, or rapid

Seed Spread Rate: Relative speed for expanding population from seed production and distribution: slow, moderate, or rapid

Seedling Vigor: Relative measure of seedling development: low, medium, or high

Palatable Browse: Relative comparison of leaves, young shoots, and other vegetative growth consumed by goats and deer: low, medium, or high

Palatable Graze: Relative comparison of leaves, young shoots, and other vegetative growth consumed by grazers such as cattle, horses, and sheep: low, medium, or high

Protein Potential: Relative comparison of protein amount available to browsers and grazers: low, medium, or high

Appendix 2c. Introduced Cool Season Grass Characteristics for Planning Conservation Plantings

Common Name	smooth brome	hard fescue	red fescue	sheep fescue	tall fescue	kentucky bluegrass	creeping meadow foxtail[1]
Scientific Name	*Bromus inermis*	*Festuca brevipila*	*Festuca rubra*	*Festuca ovina*	*Schedonorus phoenix*	*Poa pratensis*	*Alopecurus arundinaceus*[1]
Duration	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial
Growth Habit	Graminoid	Graminoid	Graminoid	Graminoid	Graminoid	Graminoid	Graminoid
Native Status	L48 (NI)	L48 (I)	L48 (NI)	L48 (I)	L48 (I)	L48 (NI)	L48 (I)
Regional Wetland Indicator Status	1NI	1NI	1 (FACU)	1NI	1NI	1 (FACU)	1NI
Active Growth Period	Spring, Summer, Fall	Spring	Spring and Fall	Spring	Spring and Fall	Spring, Summer, Fall	Spring and Summer
After Harvest Regrowth Rate	Slow	Slow	Moderate	Moderate	Rapid	Moderate	Rapid
Bloat	None	None	None	None	None	None	None
C:N Ratio	Medium	High	Medium	Medium	Low	Low	High
Flower Color	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
Foliage Texture	Fine	Fine	Fine	Fine	Coarse	Fine	Fine
Growth Form	Rhizomatous	Bunch	Rhizomatous	Bunch	Rhizomatous	Rhizomatous	Rhizomatous
Growth Rate	Moderate	Slow	Moderate	Moderate	Rapid	Moderate	Rapid
Height, Mature (feet)	2.5	0.5	2	0.5	3	1.5	3
Lifespan	Long	Moderate	Long	Long	Moderate	Long	Moderate
Nitrogen Fixation	None	None	None	None	None	None	None
Shape and Orientation	Erect	Semi-Erect	Decumbent	Semi-Erect	Semi-Erect	Erect	Erect
Toxicity	None	None	None	None	Slight	None	None
Adapted to Coarse Textured Soils	No	Yes	No	Yes	No	No	No
Adapted to Medium Textured Soils	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adapted to Fine Textured Soils	Yes	Yes	Yes	No	Yes	Yes	Yes
Anaerobic Tolerance	Low	None	None	None	Low	Low	High

[1] Species considered invasive or problematic, consider alternatives.

Appendix 2c. Introduced Cool Season Grass Characteristics for Planning Conservation Plantings (continued)

Common Name	meadow foxtail	orchard-grass	reed canary-grass[1]	perennial ryegrass	annual ryegrass	red top	timothy
Scientific Name	*Alopecurus pratensis*	*Dactylis glomerata*	*Phalaris arundinacea*[1]	*Lolium perenne*	*Lolium perenne ssp. multiflorum*	*Agrostis gigantea*	*Phleum pratense*
Duration	Perennial	Perennial	Perennial	Perennial, Annual	Annual, Perennial	Perennial	Perennial
Growth Habit	Graminoid	Graminoid	Graminoid	Graminoid	Graminoid	Graminoid	Graminoid
Native Status	L48 (I)	L48 (I)	L48 (N)	L48 (I)	L48 (I)	L48 (I)	L48 (I)
Regional Wetland Indicator Status	1 (FACW)	1 (FACU)	1 (FACW+)	1 (FACU-)	1NI	1NI	1 (FACU)
Active Growth Period	Spring and Summer	Spring and Fall	Spring, Summer, Fall	Spring and Fall	Spring and Summer	Spring and Summer	Spring and Summer
After Harvest Regrowth Rate	Rapid	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Bloat	None	None	None	None	None	Low	None
C:N Ratio	Medium	Low	Medium	Low	Low	Medium	Low
Flower Color	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
Foliage Texture	coarse	Fine	Coarse	Fine	Fine	Fine	Fine
Growth Form	Rhizomatous	Bunch	Rhizomatous	Bunch	Bunch	Rhizomatous	Bunch
Growth Rate	Rapid	Moderate	Rapid	Rapid	Rapid	Rapid	Rapid
Height, Mature (feet)	3	3	5	3.5	2.5	2	3
Lifespan	Long	Moderate	Long	Short	Short	Short	Moderate
Nitrogen Fixation	None	None	None	None	None	None	None
Shape and Orientation	Erect	Erect	Erect	Erect	Erect	Decumbent	Erect
Toxicity	None	None	Slight	None	None	None	None
Adapted to Coarse Textured Soils	No	No	No	No	Yes	No	No
Adapted to Medium Textured Soils	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adapted to Fine Textured Soils	Yes	No	Yes	Yes	Yes	Yes	Yes
Anaerobic Tolerance	None	Low	High	Low	Low	Medium	Low

[1] Species considered invasive or problematic, consider alternatives.

Appendix 2c. Introduced Cool Season Grass Characteristics for Planning Conservation Plantings (continued)

Common Name	smooth brome	hard fescue	red fescue	sheep fescue	tall fescue	kentucky bluegrass	creeping meadow foxtail[1]
Scientific Name	*Bromus inermis*	*Festuca brevipila*	*Festuca rubra*	*Festuca ovina*	*Schedonorus phoenix*	*Poa pratensis*	*Alopecurus arundinaceus*[1]
CaCO3 Tolerance	Low	High	High	None	High	High	Medium
Drought Tolerance	Medium	High	Medium	High	Medium	Low	Medium
Fertility Requirement	High	Low	High	Medium	Medium	High	Medium
Moisture Use	medium	Low	Medium	Low	Medium	High	medium
pH (Minimum)	5.5	4.5	5	5.5	5	5	5.5
pH (Maximum)	8	8.5	7.5	7.5	9	8.4	8.4
Root Depth, Minimum (inches)	12	10	12	10	12	10	12
Salinity Tolerance	Medium	None	Low	Low	Medium	Low	High
Shade Tolerance	Intolerant	Intolerant	Tolerant	Intermediate	Intermediate	Intolerant	Intolerant
Temperature, Minimum (°F)	-43	-38	-43	-43	-38	-38	-43
Bloom Period	Late Spring	Late Spring	Mid Spring	Late Spring	Late Spring	Mid Spring	Mid Spring
Seeds per Pound	142,880	591,920	454,087	530,320	205,720	1,389,840	786,064
Seed Spread Rate	Slow	Slow	Slow	Moderate	Moderate	Slow	Slow
Seedling Vigor	High	Medium	Medium	Medium	High	Low	Low
Vegetative Spread Rate	Rapid	None	Rapid	None	Slow	Rapid	Rapid
Palatable Browse Animal	Medium	Medium	Medium	Medium	Low	High	High
Palatable Graze Animal	High	Low	Low	Medium	Medium	High	High
Protein Potential	Medium	Medium	Medium	Low	Medium	Medium	Medium

[1] Species considered invasive or problematic, consider alternatives.

Appendix 2c. Introduced Cool Season Grass Characteristics for Planning Conservation Plantings (continued)

Common Name	meadow foxtail	orchard-grass	reed canary-grass[1]	perennial ryegrass	annual ryegrass	red top	timothy
Scientific Name	*Alopecurus pratensis*	*Dactylis glomerata*	*Phalaris arundinacea*[1]	*Lolium perenne*	*Lolium perenne ssp. multiflorum*	*Agrostis gigantea*	*Phleum pratense*
CaCO3 Tolerance	High	Low	Medium	Medium	Medium	Low	High
Drought Tolerance	Low	Medium	Low	Low	Low	Low	Low
Fertility Requirement	High	Medium	High	High	Medium	Low	Medium
Moisture Use	High	Medium	High	High	Medium	Medium	Medium
pH (Minimum)	5.8	5	5.5	5	5	4.5	5
pH (Maximum)	8	7.5	8	8	7.9	8	7.8
Root Depth, Minimum (inches)	12	12	14	10	8	14	10
Salinity Tolerance	Low	Medium	Medium	High	High	Low	Low
Shade Tolerance	Intolerant	Tolerant	Intolerant	Intolerant	Intermediate	Intolerant	Intermediate
Temperature, Minimum (°F)	-38	-33	-38	-18	-8	-38	-43
Bloom Period	Spring	Mid Spring	Late Spring	Mid Spring	Early Spring	Mid Spring	Late Spring
Seeds per Pound	406,880	427,200	537,920	240,400	217,000	4,851,200	1,163,200
Seed Spread Rate	Moderate	Slow	Slow	Moderate	Moderate	Slow	Slow
Seedling Vigor	High	High	Low	High	High	High	Medium
Vegetative Spread Rate	Slow	None	Rapid	None	None	Rapid	None
Palatable Browse Animal	Medium	Medium	Low	Low	Low	High	High
Palatable Graze Animal	High	High	Medium	High	Medium	High	High
Protein Potential	Medium	Medium	Medium	Medium	High	Medium	Medium

[1] Species considered invasive or problematic, consider alternatives.

Appendix 2d. Native Cool Season Grass and Sedges for Planning Conservation Plantings

Common name	autumn bent-grass/ upland bentgrass	rough bentgrass	fringed brome	Canada bluejoint	fowl bluegrass	Canada wildrye
Scientific Name	*Agrostis perennans*	*Agrostis scabra*	*Bromus ciliatus*	*Calamagrostis canadensis*	*Poa palustris*	*Elymus canadensis*
Duration	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial
Growth Habit	Graminoid	Graminoid	Graminoid	Graminoid	Graminoid	Graminoid
Native Status	L48 (N)	L48 (N)	L48 (N)	L48 (N)	L48 (N)	L48 (N)
Regional Wetland Indicator Status	1 (FACU)	1 (FAC)	1 (FACW)	1 (FACW+)	1 (FACW)	1 (FACU+)
Active Growth Period	Spring, Summer, Fall	Spring	Spring and Summer	Spring	Spring and Summer	Spring, Summer, Fall
After Harvest Regrowth Rate	Moderate	Slow	Slow	Moderate	Slow	Moderate
Bloat	None	None	None	None	None	None
C:N Ratio	Low	medium	Medium	N/A	Medium	Medium
Flower Color	Green	Green	Yellow	Green	Yellow	Yellow
Foliage Texture	Medium	Fine	Fine	Medium	Fine	Coarse
Growth Form	Rhizomatous	Bunch	Bunch	Rhizomatous	Bunch	Bunch
Growth Rate	Moderate	Moderate	Moderate	Moderate	Moderate	Rapid
Height, Mature (feet)	3.5	2.5	4	4.9	4	3
Lifespan	Short	Moderate	Long	Long	Moderate	Short
Nitrogen Fixation	None	None	None	None	None	None
Shape and Orientation	Decumbent	Erect	Erect	Erect	Erect	Erect
Toxicity	None	None	None	None	None	None
Adapted to Coarse Textured Soils	No	No	Yes	No	No	Yes
Adapted to Medium Textured Soils	Yes	Yes	No	Yes	Yes	Yes
Adapted to Fine Textured Soils	Yes	Yes	Yes	Yes	Yes	Yes
Anaerobic Tolerance	High	Low	Low	High	Medium	Low
CaCO3 Tolerance	None	Low	Medium	Medium	Medium	High
Drought Tolerance	Low	Low	Low	Low	Low	Medium

Appendix 2d. Native Cool Season Grass and Sedges for Planning Conservation Plantings (continued)

Common name	riverbank wildrye	Virginia wildrye	broom sedge	fox sedge	squarrose sedge
Scientific Name	*Elymus riparius*	*Elymus virginicus*	*Carex scoparia*	*Carex vulpinoidea*	*Carex squarrosa*
Duration	Perennial	Perennial	Perennial	Perennial	Perennial
Growth Habit	Graminoid	Graminoid	Graminoid	Graminoid	Graminoid
Native Status	L48 (N)	L48 (N)	L48 (N)	L48 (N)	L48 (N)
Regional Wetland Indicator Status	1 (FACW)	1 (FACW-)	1 (FACW)	1 (OBL)	1 (FACW)
Active Growth Period	Spring and Summer	Spring	Spring and Summer	Spring	Spring and Summer
After Harvest Regrowth Rate	Slow	Slow	Slow	Slow	Slow
Bloat	None	None	None	None	None
C:N Ratio	Medium	Medium	Medium		Medium
Flower Color	Yellow	Yellow	Green	Green	Green
Foliage Texture	Coarse	Coarse	Medium	fine	Fine
Growth Form	Bunch	Bunch	Bunch	Bunch	Bunch
Growth Rate	Moderate	Moderate	Moderate	Moderate	Slow
Height, Mature (feet)	4.5	2.5	2.5	3.2	3
Lifespan	Moderate	Short	Long	Long	Moderate
Nitrogen Fixation	None	None	None	None	None
Shape and Orientation	Erect	Erect	Erect	Erect	Erect
Toxicity	None	None	None	None	None
Adapted to Coarse Textured Soils	Yes	Yes	No	No	No
Adapted to Medium Textured Soils	Yes	Yes	Yes	Yes	Yes
Adapted to Fine Textured Soils	Yes	Yes	Yes	Yes	Yes
Anaerobic Tolerance	Medium	Medium	High	Medium	High
CaCO3 Tolerance	Medium	Medium	Low	Medium	Low
Drought Tolerance	Low	Medium	None	Low	None

Note: Missing values are not in PLANTS Database.

Appendix 2d. Native Cool Season Grass and Sedges for Planning Conservation Plantings (continued)

Common name	autumn bent-grass/ upland bentgrass	rough bentgrass	fringed brome	Canada bluejoint	fowl bluegrass	Canada wildrye
Scientific Name	*Agrostis perennans*	*Agrostis scabra*	*Bromus ciliatus*	*Calamagrostis canadensis*	*Poa palustris*	*Elymus canadensis*
Fertility Requirement	Medium	Low	Low	Medium	Medium	Medium
Moisture Use	High	Medium	Medium	Medium	Medium	Medium
pH (Minimum)	5.5	6.0	5.5	4.5	4.9	5.0
pH (Maximum)	7.5	8.0	7.5	8.0	7.5	7.9
Root Depth, Minimum (inches)	8	12	16	16	12	16
Salinity Tolerance	None	Low	Low	None	Low	Medium
Shade Tolerance	Intermediate	Intolerant	Tolerant	Intolerant	Intermediate	Tolerant
Temperature, Minimum (°F)	-33	-38	-33	-33	-38	-43
Bloom Period	Mid Summer	Early Spring	Spring	Late Spring	Mid Spring	Late Spring
Seeds per Pound	8,000,000	5,000,000	236,000	3,837,472	1,900,000	114,000
Seed Spread Rate	Slow	Slow	Slow	Moderate	Slow	Moderate
Seedling Vigor	Low	Medium	Medium	Medium	Medium	High
Vegetative Spread Rate	Moderate	None	None	None	None	None
Palatable Browse Animal	Low	Medium	Medium	Low	Low	Medium
Palatable Graze Animal	Medium	Medium	High	Low	Low	Medium
Protein Potential	Low	Low	Low	Low	Low	Medium

Appendix 2d. Native Cool Season Grass and Sedges for Planning Conservation Plantings (continued)

Common name	riverbank wildrye	Virginia wildrye	broom sedge	fox sedge	squarrose sedge
Scientific Name	*Elymus riparius*	*Elymus virginicus*	*Carex scoparia*	*Carex vulpinoidea*	*Carex squarrosa*
Fertility Requirement	Medium	Medium	Medium	Medium	Medium
Moisture Use	High	Medium	High	Medium	Medium
pH (Minimum)	4.5	5.0	4.6	6.8	5.6
pH (Maximum)	7.2	7.0	6.9	8.9	7.3
Root Depth, Minimum (inches)	10	16	8	16	8
Salinity Tolerance	None	None	Low	None	None
Shade Tolerance	Tolerant	Tolerant	Tolerant	Intermediate	Tolerant
Temperature, Minimum (°F)	-33	-28	-38	-38	-28
Bloom Period	Mid Summer	Early Spring	Late Spring	Spring	Mid Spring
Seeds per Pound	125,000	100,000	131,200	1,297,000	320,000
Seed Spread Rate	Moderate	Moderate	Slow	Moderate	Slow
Seedling Vigor	High	Medium	Low	Medium	Low
Vegetative Spread Rate	None	None	Slow	None	Slow
Palatable Browse Animal		medium	Low		Low
Palatable Graze Animal		Low	Low	Medium	Low
Protein Potential		Low	Low	Medium	Low

Note: Missing values are not in PLANTS Database.

Appendix 2e. Native Warm Season Grass Characteristics for Planning Conservation Plantings

Common name	Bermuda-grass[1]	big bluestem	broomsedge bluestem	little bluestem	coastal panicgrass[2]	prairie cordgrass	saltmeadow cordgrass[2]
Scientific Name	*Cynodon dactylon*[1]	*Andropogon gerardii*	*Andropogon virginicus*	*Schizachyrium scoparium*	*Panicum amarum var. amarulum*[2]	*Spartina pectinata*	*Spartina patens*[2]
Duration	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial
Growth Habit	Graminoid	Graminoid	Graminoid	Graminoid	Graminoid	Graminoid	Graminoid
Native Status	L48 (I)	L48 (N)	L48 (N)	L48 (N)	L48 (N)	L48 (N)	L48 (N)
Regional Wetland Indicator Status	1 (FACU)	1 (FAC)	1 (FACU)	1 (FACU-)	N/A	1 (OBL)	1 (FACW+)
Active Growth Period	Spring, Summer, Fall	Summer	Summer	Summer and Fall	Summer	Spring and Summer	Spring and Summer
After Harvest Regrowth Rate	Rapid	Moderate	Slow	Moderate	Moderate	Moderate	Slow
Bloat	Low	Low	None	None	None	None	None
C:N Ratio	Low	Medium	High	Medium		High	High
Flower Color	Yellow	Yellow	Yellow	Yellow		Yellow	Yellow
Foliage Texture	Fine	Medium	Medium	Medium		Coarse	Medium
Growth Form	Stoloniferous	Bunch	Bunch	Bunch		Rhizomatous	Rhizomatous
Growth Rate	Rapid	Moderate	Slow	Moderate		Rapid	Moderate
Height, Mature (feet)	1.4	6	3	3		8	2
Lifespan	Long	Long	Moderate	Long		Long	Long
Nitrogen Fixation	None	None	None	None		None	None
Shape and Orientation	Prostrate	Erect	Erect	Erect		Erect	Erect
Toxicity	None	None	None	None		None	None
Adapted to Coarse Textured Soils	Yes	Yes	No	Yes		Yes	Yes
Adapted to Medium Textured Soils	Yes	Yes	Yes	Yes		Yes	Yes
Adapted to Fine Textured Soils	Yes	Yes	Yes	Yes		No	Yes
Anaerobic Tolerance	High	Medium	None	None		High	High
CaCO3 Tolerance	Medium	High	High	High		Medium	High

Note: Missing values are not in PLANTS Database.

[1] Non-native to the U.S.

[2] Non-native to parts of the Northeast check with Nature Serve Exporer website or Natural Heritage Botanist.

Appendix 2e. Native Warm Season Grass Characteristics for Planning Conservation Plantings (continued)

Common name	smooth cordgrass[2]	deertongue	eastern gamagrass[2]	Indiangrass	purpletop tridens[2]	sideoats grama[2]	switchgrass
Scientific Name	*Spartina alterniflora*[2]	*Dichanthelium clandestinum*	*Tripsacum dactyloides*[2]	*Sorghastrum nutans*	*Tridens flavus*[2]	*Bouteloua curtipendula*[2]	*Panicum virgatum*
Duration	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial
Growth Habit	Graminoid	Graminoid	Graminoid	Graminoid	Graminoid	Graminoid	Graminoid
Native Status	L48 (N)	L48 (N)	L48 (N)	L48 (N)	L48 (N)	L48 (N)	L48 (N)
Regional Wetland Indicator Status	1 (OBL)	1 (FAC+)	1 (FACW)	1 (UPL)	1 (FACU*)	N/A	1 (FAC)
Active Growth Period	Spring and Summer	Spring and Summer	Spring and Summer	Summer and Fall	Summer	Summer	Summer
After Harvest Regrowth Rate	Slow	Slow	Rapid	Moderate	Rapid	Moderate	Moderate
Bloat	None	None	None	None	None	None	None
C:N Ratio	Medium	Medium	Low	Medium	Low	Medium	Medium
Flower Color	Yellow		Yellow	Yellow	Yellow	Yellow	Yellow
Foliage Texture	Medium	Medium	Coarse	Coarse	Medium	Medium	Coarse
Growth Form	Bunch	Bunch	Bunch	Bunch	Bunch	Rhizomatous	Rhizomatous
Growth Rate	Moderate	Slow	Rapid	Moderate	Moderate	Moderate	Rapid
Height, Mature (feet)	3.5	2	5	6	2.5	3	5
Lifespan	Moderate	Long	Long	Long	Short	Moderate	Long
Nitrogen Fixation	None	None	None	None	None	None	None
Shape and Orientation	Erect	Semi-Erect	Erect	Erect	Erect	Erect	Erect
Toxicity	None	None	None	None	None	None	None
Adapted to Coarse Textured Soils	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adapted to Medium Textured Soils	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adapted to Fine Textured Soils	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Anaerobic Tolerance	High	Low	Medium	Low	Low	None	Medium
CaCO3 Tolerance	Low	Low	None	High	Low	Medium	Low

[1] Non-native to the U.S.

[2] Non-native to parts of the Northeast check with Nature Serve Exporer website or Natural Heritage Botanist.

Appendix 2e. Native Warm Season Grass Characteristics for Planning Conservation Plantings (continued)

Common name	Bermuda-grass[1]	big bluestem	broomsedge bluestem	little bluestem	coastal panicgrass[2]	prairie cordgrass	saltmeadow cordgrass[2]
Scientific Name	*Cynodon dactylon*[1]	*Andropogon gerardii*	*Andropogon virginicus*	*Schizachyrium scoparium*	*Panicum amarum var. amarulum*[2]	*Spartina pectinata*	*Spartina patens*[2]
Drought Tolerance	Medium	High	High	High		Low	Low
Fertility Requirement	High	Low	Low	Low		Medium	Medium
Moisture Use	High	Low	Medium	Low		High	High
pH (Minimum)	5	6	4.9	5	4.5	6	5.5
pH (Maximum)	8	7.5	7	8.4	7.5	8.5	7.5
Root Depth, Minimum (inches)	14	20	14	14		18	10
Salinity Tolerance	High	Medium	Low	None		Low	High
Shade Tolerance	Intolerant	Intolerant	Intolerant	Intolerant		Intolerant	Intolerant
Temperature, Minimum (°F)	-8	-46	-18	-38		-38	-3
Bloom Period	Mid Spring	Summer	Late Spring	Summer		Mid Summer	Late Spring
Seeds per Pound	2,071,120	144,240	800,000	240,670	325,000	638,863	110,000
Seed Spread Rate	Slow	Slow	Slow	Moderate		Slow	None
Seedling Vigor	Low	Low	Low	Low		Medium	Low
Vegetative Spread Rate	Rapid	Slow	None	None		Rapid	Rapid
Palatable Browse Animal	Medium	Medium	Low	Medium		Low	Low
Palatable Graze Animal	High	High	Low	High		Medium	Low
Protein Potential	Medium	Medium	Low	Medium		Low	Low

Note: Missing values are not in PLANTS Database.

[1] Non-native to the U.S.

[2] Non-native to parts of the Northeast check with Nature Serve Exporer website or Natural Heritage Botanist.

Appendix 2e. Native Warm Season Grass Characteristics for Planning Conservation Plantings (continued)

Common name	smooth cordgrass[2]	deertongue	eastern gamagrass[2]	Indiangrass	purpletop tridens[2]	sideoats grama[2]	switchgrass
Scientific Name	*Spartina alterniflora*[2]	*Dichanthelium clandestinum*	*Tripsacum dactyloides*[2]	*Sorghastrum nutans*	*Tridens flavus*[2]	*Bouteloua curtipendula*[2]	*Panicum virgatum*
Drought Tolerance	None	High	Low	Medium	High	Medium	Medium
Fertility Requirement	Medium	Low	High	Low	Low	Medium	High
Moisture Use	High	Low	High	Medium	Low	Medium	Medium
pH (Minimum)	5.4	4	5.1	4.8	4.5	5.5	4.5
pH (Maximum)	7	7.5	7.5	8	6.5	8.5	8
Root Depth, Minimum (inches)	12	16	20	24	10	12	12
Salinity Tolerance	High	Low	None	Medium	None	Low	Medium
Shade Tolerance	Intolerant	Intolerant	Intolerant	Intolerant	Intolerant	Intolerant	Intolerant
Temperature, Minimum (°F)	-23	-33	-23	-38	-23	-43	-43
Bloom Period	Late Spring	Early Summer	Early Summer	Late Spring	Late Summer	Mid Spring	Mid Summer
Seeds per Pound	20,000	350,000	7,200	174,720	465,000	159,200	259,000
Seed Spread Rate	Slow	Slow	Slow	Slow	Rapid	Slow	Slow
Seedling Vigor	Low	Low	Low	Medium	High	Medium	Medium
Vegetative Spread Rate	Rapid	None	Moderate	Moderate	None	None	Slow
Palatable Browse Animal	Low	High	High	Medium	High	Medium	Medium
Palatable Graze Animal	Medium	Low	High	High	High	High	High
Protein Potential	Low	Low	High	Medium	Medium	Medium	Medium

[1] Non-native to the U.S.

[2] Non-native to parts of the Northeast check with Nature Serve Exporer website or Natural Heritage Botanist.

Appendix 2f. Warm Season Grass Cultivar Recommendations for the Northeast

Species	Cultivar	Origin State	USDA PLANT Hardiness Zone[1]
Bluestem, big	Bison	North Dakota	2,3,4
Bluestem, big	Bonilla	South Dakota	4,5
Bluestem, big	Bonanza	Nebraska	5,6
Bluestem, big	Champ	Nebraska/Iowa	5,6
Bluestem, big	Goldmine	Kansas	5,6,7
Bluestem, big	Kaw	Kansas	5,6,7
Bluestem, big	Niagara	New York	3, 4, 5, 6
Bluestem, big	Long Island, germplasm	Long Island, New York	6,7
Bluestem, big	Pawnee	Nebraska	5,6
Bluestem, big	Prairieview	Michigan	4,5
Bluestem, big	Rountree	Missouri	4,5,6
Bluestem, big	Southlow	Michigan	4,5
Bluestem, big	Sunnyview	South Dakota/Minnesota	4,5
Bluestem, big	Suther	North Carolina	6,7
Bluestem, little	Albany Pinebush germplasm	New York	4,5
Bluestem, little	Aldous	Kansas	4,5,6
Bluestem, little	Blaze	Nebraska	4,5
Bluestem, little	Camper	Nebraska	4,5
Bluestem, little	Connecticut germplasm	Connecticut	5,6
Bluestem, little	Long Island, germplasm	Long Island, New York	6,7
Bluestem, little	PA germplasm	Pennsylvannia	5,6
Bluestem, little	Prairieview	Michigan	4,5
Bluestem, little	Suther	North Carolina	6,7
Bluestem, little	Southlow	Michigan	4,5
Bluestem, coastal little	Dune crest germplasm	New Jersey, Maryland, Delaware	6,7

This table is adapted from Vegetating with Native Grasses in Northeastern North America USDA-NRCS and Ducks Unlimited Canada (1998).

[1] Trials have shown that from an adaptability standpoint some warm season grasses can be moved along latitudinal lines and within plant hardiness zones. In some instances disease susceptibility could be an issue.

Appendix 2f. Warm Season Grass Cultivar Recommendations for the Northeast (continued)

Species	Cultivar	Origin State	USDA PLANT Hardiness Zone[1]
Bluestem, sand	Goldstrike	Nebraska	3,4,5
Cordgrass, salt meadow	Avalon	New Jersey	4,5
Cordgrass, smooth	Bayshore	New Jersey	4,5
Deertongue	Tioga	New York	3,4,5
Gamagrass, eastern	Pete	Kansas	4,5,6
Gamagrass, eastern	Meadowcrest	Maryland	6,7
Grama, sideoats	Butte	Nebraska	4,5
Grama, sideoats	El Reno	Kansas	4,5,6
Grama, sideoats	Killdeer	North Dakota	2,3
Grama, sideoats	Pierre	South Dakota	4,5
Grama, sideoats	Trailway	Nebraska	3,4
Indiangrass	Cheyenne	Oklahoma	6,7
Indiangrass	Chief	Nebraska/Kansas	4,5
Indiangrass	Coastal germplasm	Connecticut, Rhode Island, Massachusetts	5,6,7
Indiangrass	Holt	Nebraska	4,5
Indiangrass	Lometa	Texas	6,7
Indiangrass	Long Island, germplasm	Long Island, New York	6,7
Indiangrass	NE-54	Nebraska	3,4,5
Indiangrass	Osage	Kansas/Oklahoma	6,7
Indiangrass	Oto	Nebraska/Kansas	4,5
Indiangrass	Pennsylvania germplasm	Pennsylvannia	4,5
Indiangrass	Prairieview	Michigan	4,5
Indiangrass	Rumsey	Missouri	4,5,6
Indiangrass	Scout	Nebraska	4,5
Indiangrass	Suther	North Carolina	6,7

[1] Trials have shown that from an adaptability standpoint some warm season grasses can be moved along latitudinal lines and within plant hardiness zones. In some instances disease susceptibility could be an issue.

Appendix 2f. Warm Season Grass Cultivar Recommendations for the Northeast (continued)

Species	Cultivar	Origin State	USDA PLANT Hardiness Zone[1]
Indiangrass	Southlow	Michigan	4,5
Indiangrass	Tomahawk	North Dakota/South Dakota	2,3,4
Indiangrass	Warrior	Nebraska/Kansas	4,5
Lovegrass, sand	Bend	Kansas	5,6
Lovegrass, sand	NE-27	Nebraska	3,4,5
Panicgrass, coastal[2]	Atlantic	Virginia	6,7
Switchgrass	Blackwell	Oklahoma	5,6,7
Switchgrass	Bomaster	North Carolina	6,7,8
Switchgrass	Carthage	North Carolina	6,7
Switchgrass	Cave-In-Rock	Illinois/Missouri	5,6,7
Switchgrass	Dacotah	North Dakota	2,3,4
Switchgrass	Forestburg	Kansas	4,5
Switchgrass	High Tide	Maryland	5,6,7
Switchgrass	Kanlow	Kansas/Oklahoma	6,7,8
Switchgrass	Long Island, germplasm	Long Island, New York	6,7
Switchgrass	Nebraska 28	Nebraska	4,5
Switchgrass	Pathfinder	Nebraska/Kansas	4,5
Switchgrass	Performer	North Carolina	5,6,7
Switchgrass	Shawnee	Illinois	5,6,7
Switchgrass	Shelter	West Virginia	5,6
Switchgrass	Sunburst	South Dakota	4,5
Switchgrass	Southlow	Michigan	4,5
Switchgrass	Summer	Nebraska	3,4
Switchgrass	Trailblazer	Nebraska	3,4
Switchgrass	Timber	North Carolina	6,7,8

[1] Trials have shown that from an adaptability standpoint some warm season grasses can be moved along latitudinal lines and within plant hardiness zones. In some instances disease susceptibility could be an issue.

[2] This is the only cultivar of coastal panicgrass. It is not reliably winter hardy north of central Pennsylvania, PHZ 6. However, it is often used as a temporary companion throughout the region due to its good seedling vigor, especially on droughty sites.

Big bluestem, *Andropogon gerardii*

Deertongue, *Dicanthelium clandestinum*

Indiangrass, *Sorghastrum nutans*

Switchgrass, *Panicum virgatum*

Appendix 2g. Introduced Legume Characteristics for Planning Conservation Plantings

Common name	alfalfa	birdsfoot trefoil[1]	alsike clover	kura clover	red clover	white clover	sweetclover, yellow[1]
Scientific Name	*Medicago sativa*	*Lotus corniculatus*[1]	*Trifolium hybridum*	*Trifolium ambiguum*	*Trifolium pratense*	*Trifolium repens*	*Melilotus officinalis*[1]
Duration	Annual, Perennial	Perennial	Annual, Perennial	Perennial	Biennial, Perennial	Perennial	Annual, Biennial, Perennial
Growth Habit	Forb/herb	Forb/herb	Forb/herb	Forb/herb	Forb/herb	Forb/herb	Forb/herb
Native Status	L48 (I)	L48 (I)	L48 (I)	L48 (I)	L48 (I)	L48 (I)	L48 (I)
Regional Wetland Indicator Status		1 (FACU-)	1 (FACU-)		1 (FACU-)	1 (FACU-)	1 (FACU-)
Active Growth Period	Spring, Summer, Fall	Spring and Summer	Spring and Summer	Spring	Spring and Summer	Spring, Summer, Fall	Spring and Summer
After Harvest Regrowth Rate	Rapid	Rapid	Moderate	Moderate	Moderate	Rapid	Slow
Bloat	High	None	High	Low	High	Low	Medium
C:N Ratio	Low	Low	Low	Low	Low	Low	Low
Flower Color	Purple	Yellow	White	White	Red	White	Yellow
Foliage Texture	Fine	Fine	Fine	Fine	Medium	Medium	Coarse
Growth Form	Single Crown	Single Crown	Single Crown	Rhizomatous	Single Crown	Stoloniferous	Single Crown
Growth Rate	Rapid	Moderate	Rapid	Slow	Rapid	Moderate	Rapid
Height, Mature (feet)	2	2.4	2	1.5	2	0.5	6
Lifespan	Long	Moderate	Short	Moderate	Short	Moderate	Short
Nitrogen Fixation	High	Medium	High	Low	Medium	High	Medium
Shape and Orientation	Erect	Semi-Erect	Semi-Erect	Prostrate	Erect	Prostrate	Erect
Toxicity	None	None	Slight	Slight	Slight	Slight	Moderate
Adapted to Coarse Textured Soils	No	Yes	No	No	Yes	No	No
Adapted to Medium Textured Soils	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adapted to Fine Textured Soils	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Anaerobic Tolerance	None	Medium	High	Low	None	Medium	Low
CaCO3 Tolerance	High	Medium	Medium	Medium	Medium	Medium	High
Drought Tolerance	High	Medium	Low	Medium	Low	Low	High
Fertility Requirement	High	Medium	Medium	Medium	Medium	High	High

Note: Missing values are not in PLANTS Database.

[1] Species considered invasive or problematic, consider alternatives.

Appendix 2g. Introduced Legume Characteristics for Planning Conservation Plantings (continued)

Common name	alfalfa	birdsfoot trefoil[1]	alsike clover	kura clover	red clover	white clover	sweetclover, yellow[1]
Scientific Name	*Medicago sativa*	*Lotus corniculatus*[1]	*Trifolium hybridum*	*Trifolium ambiguum*	*Trifolium pratense*	*Trifolium repens*	*Melilotus officinalis*[1]
Moisture Use	High	Medium	High	Medium	Medium	Medium	Medium
pH (Minimum)	6	5	5.6	5.7	5.5	5.2	6.5
pH (Maximum)	8.5	8	7.5	7.4	7.6	8	8.2
Root Depth, Minimum (inches)	24	14	12	12	12	12	16
Salinity Tolerance	Medium	High	Low	None	Low	Low	High
Shade Tolerance	Intolerant	Intolerant	Intolerant	Intolerant	Intolerant	Intolerant	Intolerant
Temperature, Minimum (°F)	-43	-43	-38	-34	-34	-62	-38
Bloom Period	Spring	Early Spring	Late Spring	Early Summer	Late Spring	Late Spring	Summer
Seeds per Pound	226,800	369,840	680,400	152,212	272,160	711,867	258,560
Seed Spread Rate	Slow	Slow	Slow	Slow	Slow	Slow	Rapid
Seedling Vigor	High	Low	Medium	Low	High	Low	High
Vegetative Spread Rate	Slow	None	None	Slow	None	Moderate	None
Palatable Browse Animal	High	High	High	High	High	High	Low
Palatable Graze Animal	High	High	High	High	High	High	Medium
Protein Potential	High	High	High	High	High	High	High

[1] Species considered invasive or problematic, consider alternatives.

Appendix 2h. Native Legume Characteristics for Planning Conservation Plantings

Common name[1]	American vetch	Canadian milkvetch	indigo, blue false	indigo, wild	lespedeza, roundhead	lupine, sundial perennial	partridge pea	purple prairieclover	ticktrefoil, panicledleaf	ticktrefoil, showy
Scientific Name	*Vicia americana*	*Astragalus canadensis*	*Baptisia australis*	*Baptisia tinctoria*	*Lespedeza capitata*	*Lupinus perennis*	*Chamaecrista fasciculata*	*Dalea purpurea var. purpurea*	*Desmodium paniculatum*	*Desmodium canadense*
Duration	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Annual	Perennial	Perennial	Perennial
Growth Habit	Vine, Forb/herb	Forb/herb	Forb/herb	Forb/herb	Forb/herb	Forb/herb	Forb/herb	Subshrub, Forb/herb	Forb/herb	Forb/herb
Native Status	L48 (N)	L48 (N)	L48 (N)	L48 (N)	L48 (N)	L48 (N), CAN (I)	L48 (N)	L48 (N)	L48 (N)	L48 (N)
Regional Wetland Indicator Status	1 (NI)	1 (FAC)			1 (FACU-)	1 (NI)		1 (NI)	1 (UPL)	1 (FAC)
Active Growth Period	Spring and Summer	Spring, Summer, Fall		Summer	Summer	Spring and Summer	Spring	Spring and Summer	Spring and Summer	Summer
After Harvest Regrowth Rate	Moderate	Moderate		Slow	Slow	Slow		Slow	Slow	Slow
Bloat	None	None	None	None	None		None	Low	Low	None
C:N Ratio	Low	Medium		Medium	Medium		Low	Medium	Low	Medium
Flower Color	Purple	White	blue	Yellow	White	blue/pink/white	Yellow	Purple	Purple	Pink
Foliage Texture	Medium	Fine	Medium	Medium	Medium	Coarse	Medium	Coarse	Medium	Medium
Growth Form	Rhizomatous	Stoloniferous	Multiple Stem	Single Crown	Multiple Stem	Multiple Stem	Bunch	Multiple Stem	Single Crown	Multiple Stem
Growth Rate	Moderate	Moderate	Moderate	Moderate	Slow	Slow	Rapid	Moderate	Moderate	Rapid

Note: Missing values are not in PLANTS Database.

[1] Not all plants are native to the entire Northeast region refer to the Natural Heritage Botantist and Nature Serve Explorer website http://www.natureserve.org/explorer/, for state specific information.

Appendix 2h. Native Legume Characteristics for Planning Conservation Plantings (continued)

Common name[1]	American vetch	Canadian milkvetch	indigo, blue false	indigo, wild	lespedeza, roundhead	lupine, sundial perennial	partridge pea	purple prairieclover	ticktrefoil, panicledleaf	ticktrefoil, showy
Scientific Name	*Vicia americana*	*Astragalus canadensis*	*Baptisia australis*	*Baptisia tinctoria*	*Lespedeza capitata*	*Lupinus perennis*	*Chamaecrista fasciculata*	*Dalea purpurea var. purpurea*	*Desmodium paniculatum*	*Desmodium canadense*
Height, Mature (feet)	1.3	0.5	4	2.5	2.6	1.5	2.4	3	3	4
Lifespan	Moderate	Short		Moderate	Long	Short		Moderate	Moderate	Moderate
Nitrogen Fixation	Low	Low		Low	Medium		Medium	Low	Low	Medium
Shape and Orientation	Decumbent	Prostrate	Erect	Erect	Erect	Erect	Erect	Erect	Erect	Erect
Toxicity	None	Slight	Moderate	None	None		Slight	None	None	None
Adapted to Coarse Textured Soils	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Adapted to Medium Textured Soils	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adapted to Fine Textured Soils	No	No		No	No	No	No	Yes	Yes	Yes
Anaerobic Tolerance	None	Medium	None		None	None	None	None	None	Low
CaCO3 Tolerance	Low	Low		High	Medium			Medium	None	Medium
Drought Tolerance	High	Medium	High	High	High	High	Medium	Medium	Medium	Medium
Fertility Requirement	High	Medium	Low	Low	Low	Low	Medium	Medium	Low	Low
Moisture Use	Low	Medium	Low	Low	Low	Low	Medium	Medium	Low	Low
pH (Minimum)	5.9	6		5.8	5.7	5	5.5	6	6	5

Note: Missing values are not in PLANTS Database.

[1] Not all plants are native to the entire Northeast region refer to the Natural Heritage Botantist and Nature Serve Explorer website http://www.natureserve.org/explorer/, for state specific information.

Appendix 2h. Native Legume Characteristics for Planning Conservation Plantings (continued)

Common name[1]	American vetch	Canadian milkvetch	indigo, blue false	indigo, wild	lespedeza, roundhead	lupine, sundial perennial	partridge pea	purple prairieclover	ticktrefoil, panicledleaf	ticktrefoil, showy
Scientific Name	*Vicia americana*	*Astragalus canadensis*	*Baptisia australis*	*Baptisia tinctoria*	*Lespedeza capitata*	*Lupinus perennis*	*Chamaecrista fasciculata*	*Dalea purpurea var. purpurea*	*Desmodium paniculatum*	*Desmodium canadense*
pH (Maximum)	7.2	8		7	8.2	7	7.5	8	7	7.5
Root Depth, Minimum (inches)	10	10		16	18		14	16	6	not available
Salinity Tolerance	None	None		None	None		None	None	None	None
Shade Tolerance	Intolerant	Intolerant	Intolerant	Intolerant	Intolerant	Intolerant	Tolerant	Intolerant	Intermediate	Tolerant
Temperature, Minimum (°F)	-38	-38	-30	2	-28		-3	-38	-13	-30
Bloom Period	Late Spring	Mid Summer	Early summer	Mid Summer	Late Summer	Late Spring	Early Summer	Summer	Late Summer	Summer
Seeds per Pound	32,833	270,500	22,000	300,000	174,000	18,800	65,000	317,000	200,000	80,000
Seed Spread Rate	Slow	Slow	Slow	Slow	Slow	Slow	Rapid	Slow	Rapid	Moderate
Seedling Vigor	Low	Medium	Low	Low	Low	Low	High	Medium	High	Low
Vegetative Spread Rate	Slow	Slow	Slow	None	None	None	None	None	None	None
Palatable Browse Animal	High	Low	Low	Medium	Medium		High	Medium	Medium	Medium
Palatable Graze Animal	High	Low	Low	Low	Low		Medium	Medium	Medium	Low
Protein Potential	High	Medium		Low	Medium		High	High		Medium

Note: Missing values are not in PLANTS Database.

[1] Not all plants are native to the entire Northeast region refer to the Natural Heritage Botantist and Nature Serve Explorer website http://www.natureserve.org/explorer/, for state specific information.

Blue false indigo, *Baptisia tinctoria*

Wild bergamot, *Monarda fistulosa*

Black-eyed Susan, *Rudbeckia hirta*

Wildflower plantings can enhance pollinator habitat for horticultural crops.

Blue vervain, *Verbena urticifolia*

Plains coreopsis, *Coreopsis tinctoria*

Virginia mountain mint, *Pycnanthemum virginianum*

Appendix 2i. Wildflower Plant Characteristics for Pollinator and Conservation Plantings in the Northeast

Common Name	Scientific Name[1]	Pollinator Ranking[2]	Plant Hardiness Zone	Bloom Time	Bloom Color	Ht (ft)	Wetland Indicator	pH
aster bigleaf	*Eurybia macrophylla*	medium	3-8	july-oct	purple	2-4	FACU	4.9-6.9
aster, calico	*Symphyotrichum lateriflorum*	high	3-6	aug-sept	white/ changing	2-5	FACW-	6.1-6.5
aster, flat top white	*Doellingeria umbellata*	medium-low	3-8	july-sept	white	2-4	FACW	5.6-7.5
aster, hairy white oldfield	*Symphyotrichum pilosum*	high	4-10	aug-oct	white	2-4	UPL	5.4-7
aster, New England	*Symphyotrichum novae-angliae*	high	4-8	aug-oct	purple	2-6	FACW	5.6-7.5
aster, New York	*Symphyotrichum novi-belgii*	high	4-8	aug-oct	purple	3-5	FACW	5.5-7
aster, smooth blue	*Symphyotrichum laeve*	high	4-6	aug-oct	blue/ purple	2-5	FACU	5.8-7.8
aster, zigzag (crooked stem)	*Symphyotrichum prenanthoides*	high	4-8	july-sept	pink/ purple	2-4	FAC	5.5-7.2
beardtongue, hairy	*Penstemon hirsutus*	high	4-9	july-aug	Pale violet	2-3	FACU	6.0-7.5
beard tongue, tall white	*Penstemon digitalis*	high	4-8	may-july	white	2-5	FAC	5.5-7
beebalm, spotted	*Monarda punctata*	very high	5-10	july-aug	pink/ white	1-3	UPL	6.8-7.2
bergamot, purple	*Monarda media*	very high	4-9	june-aug	purple	2-4	FACW	6.0-7.8
bergamot, wild	*Monarda fistulosa*	very high	3-7	june-july	purple/ dark pink	2-5	UPL	6-8
black-eyed Susan	*Rudbeckia hirta*	medium-low	5-9	june-sept	yellow/ orange	2-3	FACU	6-7
blazing star, marsh	*Liatris spicata*	high	3-9	july-aug	purple	2-4	FAC+	5.6-7.5
blazing star, tall (rough)	*Liatris aspera*	high	3-8	july-aug	purple	2-4	FACU	6.6-7.5
boneset	*Eupatorium perfoliatum*	high	4-7	july-sept	white	2-5	FACW+	6.1-7.8
cardinal flower	*Lobelia cardinalis*	high	4-8	june-aug	red	1-4	FACW+	5.8-7.8
chicory, blue	*Cichorium intybus*	very low	4-8	july-sept	purple	1-4	FACU	6.0-7.5
coneflower, gray-headed	*Ratibida pinnata*	medium	3-7	july-aug	yellow	3-5	FAC	5.6-6.8
coneflower, purple	*Echinacea purpurea*	high	3-8	july-oct	purple	2-4	FAC	6.5-7.2
coreopsis, lanced-leaved	*Coreopsis lanceolata*	medium	3-8	june-aug	yellow	2-4	FACU	6.0-7.0

Appendix 2i. Wildflower Plant Characteristics for Pollinator and Conservation Plantings in the Northeast (continued)

Common Name	Light Needs	Vegetative Spread	Seedling Vigor	Persis-tence[6]	Seeds/lb	Cost (lb) ($)[3]	Ease of establishment plus other comments[4]
aster bigleaf	full	mod	medium	medium	800,000	240	provides wildlife habitat, can tolerate some shade
aster, calico	full-shade	some	n/a	medium	4,000,000	260	found in forested areas, horizontal stems
aster, flat top white	full	n/a	n/a	medium	859,000	180	host to pearl crescent, and silvery checkerspot butterflies
aster, hairy white oldfield	full	rapid	high	high	1,056,000	200	*showing invasive potential, seed at low rates if used*
aster, New England	full to partial	n/a	n/a	high	700,000	248	provides food and cover for wildlife and butterflies
aster, New York	full	mod	low	medium	700000	220	prone to mildew
aster, smooth blue	full	mod	low	high	880,000	180	fibrous root system
aster, zigzag (crooked stem)	partial to shade	mod	low	high	700,000	180	provides nectar for butterflies
beardtongue, hairy	full-shade	none	n/a	high	2,000,000	240	benefits from stratification
beard tongue, tall white	full to partial	mod	medium	high	400,000	108	a durable early plant, benefits from stratification
beebalm, spotted	full	mod	n/a	medium	1,440,000	180	avoid wet soils
bergamot, purple	full to partial	mod	n/a	high	1,120,000	196	attracts bees and butterflies
bergamot, wild	full to partial	mod	medium	high	1,200,000	220	provides nectar for bees, hummingbirds, and butterflies
black-eyed Susan	full to partial	none	medium	high	1,500,000	24	used for cover, landscaping, and plant diversity
blazing star, marsh	full to partial	slow	low	low	100,000	148	good for rain gardens
blazing star, tall (rough)	full	slow	n/a	low	256,000	400	scarify seed helps, shortest and last to bloom of liatris
boneset	full to partial	n/a	n/a	low	1,520,000	200	
cardinal flower	full to partial	none	high	low	7,320,000	560	provides nectar for bees, hummingbirds, and butterflies
chicory, blue	full to partial	none	high	medium	426,400	16	roadside weed
coneflower, gray-headed	full to partial	none	medium	high	625,000	48	roadside plantings, prairie restoration, wildlife cover, prairie diversity
coneflower, purple	full to partial	mod	medium	high	115,000	28	easy to grow, common garden plant
coreopsis, lanced-leaved	full	none	high	high	210,000	14	can tolerate regular mowing

Appendix 2i. Wildflower Plant Characteristics for Pollinator and Conservation Plantings in the Northeast (continued)

Common Name	Scientific Name[1]	Pollinator Ranking[2]	Plant Hardiness Zone	Bloom Time	Bloom Color	Ht (ft)	Wetland Indicator	pH
coreopsis, plains	*Coreopsis tinctoria*	low	4-6	june-aug	yellow	2-4	FAC-	5.2-7.8
culver's root	*Veronicastrum virginicum*	high	4-8	july-aug	white	2-5	FAC	6.6-7.8
evening primrose	*Oenothera biennis*	medium	4-8	june-aug	yellow	4-5	FACU	6.1-7.8
golden alexanders	*Zizia aurea*	low	3-8	june-july	yellow	1-2	FAC	6.1-7.8
goldenrod, bluestem	*Solidago caesia*	high	3-9	aug-oct	yellow	1-4	FACU	5.5-7
goldenrod, early	*Solidago juncea*	high	4-8	july-sept	yellow	2-5	UPL	5.0-7.0
goldenrod, grass-leaved	*Euthamia graminifolia*	medium-low	2-8	aug-sep	yellow	3-5	FAC	n/a
goldenrod, gray	*Solidago nemoralis*	high	4-8	aug-oct	yellow	1-3	UPL	6.5-7.5
goldenrod, rough	*Solidago patula*	high	3-8	sept-oct	yellow	4-5	FACW	4.5-7
goldenrod, showy	*Solidago speciosa*	high	5-9	aug-sept	yellow	2-5	UPL	5.1-7.5
indian hemp	*Apocynum cannabinum*	very high	4-8	june-aug	white	2-4	FACU	4.5-7
indigo, blue false	*Baptisia australis*	medium	3-8	may-july	purple/ blue	3-5	FACU	5.8-7.2
indigo, wild	*Baptisia tinctoria*	medium	3-9	june-aug	yellow	1-3	FAC-	5.8-7
joe pye weed, spotted	*Eupatoriadelphus maculatus*	high	5-9	july-aug	pink-purple	2-5	FACW	5.5-7
lupine, wild	*Lupinus perennis*	high	3-9	late may-june	blue	1-2	FACU	4.6-7.2
milkweed, butterfly	*Asclepias tuberosa*	very high	4-9	late-june-aug	orange	1-2	UPL	4.8-6.8
milkweed, common	*Asclepias syriaca*	very high	3-9	june-aug	pink purple	1-4	FACU	5.6-7.5
milkweed, swamp	*Asclepias incarnata*	very high	3-7	july-aug	pink	2-4	OBL	5-8
lespedeza, round-headed	*Lespedeza capitata*	low	4-6	aug-sept	white	2-4	FACU-	5.7-8.2
lobelia, great blue	*Lobelia siphilitica*	very high	3-8	july-sept	purple	2-5	FACW+	6.0-7.5
monkey flower, Allegheny	*Mimulus ringens*	medium	3-9	july-aug	light purple	1-3	OBL	5.6-7.5
New York ironweed	*Vernonia noveboracensis*	high	5-9	aug-sept	purple	4-6	FACW+	5.1-7.5

Appendix 2i. Wildflower Plant Characteristics for Pollinator and Conservation Plantings in the Northeast (continued)

Common Name	Light Needs	Vegetative Spread	Seedling Vigor	Persis-tence[6]	Seeds/lb	Cost (lb) ($)[3]	Ease of establishment plus other comments[4]
coreopsis, plains	full	none	high	low	3,222,222	12	a reseeding annual, seed at low rates, may compete during establishment
culver's root	full to partial	n/a	n/a	low	12,400,000	640	attracts butterflies and bees
evening primrose	full	none	high	high	1,376,000	32	biennial, *may become weedy or invasive*
golden alexanders	full to partial	n/a	n/a	medium	176,000	160	one of the earliest blooming natives, takes a couple of years to establish
goldenrod, bluestem	full to partial	slow	medium	high	4,640,000	320	wood edges
goldenrod, early	full to partial	n/a	n/a	high	700,000	200	first goldenrod of the season to bloom
goldenrod, grass-leaved	full	fast	n/a	medium	5,600,000	360	
goldenrod, gray	full	rapid	high	high	1,008,000	240	survives in low fertility soil, provides nectar for butterflies
goldenrod, rough	full-partial	rapid	medium	medium	700000	320	
goldenrod, showy	full to partial	n/a	n/a	medium	1,600,000	160	very attractive to butterflies, bees, ants, and beetles
indian hemp	full	some	medium	low	500,000	360	extensive root system, fairly aggressive
indigo, blue false	full	none	n/a	medium	22,000	140	native legume, great for mixes, bushy habit, good ground cover, poor seedling vigor
indigo, wild	full	none	low	medium	300,000	400	very low maintenance, scarify seed
joe pye weed, spotted	full to partial	slow	n/a	low	2,880,000	220	attracts butterflies
lupine, wild	full to partial	none	n/a	medium	18,800	200	provides food and habitat for butterflies, not for restoration
milkweed, butterfly	full to partial	none	low	low	70,000	300	attractive to monarchs
milkweed, common	full to partial	high	n/a	low	64,000	160	attractive to monarchs, poor seedling vigor
milkweed, swamp	full to partial	slow	low	medium	75,000	280	good for wetlands, great for monarch, high deer resistance
lespedeza, round-headed	full	none	low	medium	159,000	180	provides food for birds and small wildlife. forms a dense cover
lobelia, great blue	full to partial	n/a	n/a	low	6,400,000	260	
monkey flower, Allegheny	full to partial	n/a[5]	n/a	low	36,800,000	160	attracts butterflies, good for wet areas
New York ironweed	full to partial	none	medium	medium	300,000	210	deer and rabbit resistance

Appendix 2i. Wildflower Plant Characteristics for Pollinator and Conservation Plantings in the Northeast (continued)

Common Name	Scientific Name[1]	Pollinator Ranking[2]	Plant Hardiness Zone	Bloom Time	Bloom Color	Ht (ft)	Wetland Indicator	pH
partridge pea	*Chamaecrista fasciculata*	high	3-8	june-aug	yellow	2-5	FACU	5.5-7.5
purple giant hyssop	*Agastache scrophulariifolia*	very high	4-6	july-sept	purple	2-4	FACW	6.5-7.0
senna, wild	*Senna hebecarpa*	medium	4-9	july-aug	yellow	4-6	FAC	6.5-7.5
sneezeweed, common	*Helenium autumnale*	high	3-8	aug-sept	yellow	2-5	FACW+	4.0-7.5
spiderwort, Ohio	*Tradescantia ohiensis*	high	4-9	late may-july	purple	2-3	FAC	6.6-7.5
spiderwort, zigzag	*Tradescantia subaspera*	high	5-9	late may-aug	purple	2-3	FACW	5-6-7.8
sunflower, ashy	*Helianthus mollis*	medium	4-10	aug-sept	yellow	2-6	UPL	5.7-8.0
sunflower, giant	*Helianthus giganteus*	medium	5-11	july-sept	yellow	6-9	FAC	6.1-7.8
sunflower, oxeye (false)	*Heliopsis helianthoides*	low	3-9	july-aug	yellow	2-5	FAC	6.1-7.8
tick trefoil, showy	*Desmodium canadense*	medium-low	3-6	july-sept	pink/ purple	2-5	FAC	5.6-6.5
turtlehead	*Chelone glabra*	medium	3-8	july aug	White	2-4	FACW	5.1-6.5
vervain, blue	*Verbena hastata*	medium	3-8	june-aug	purple	2-5	FACW+	5.6-7.5
vervain, hoary	*Verbena stricta*	medium	3-9	july-aug	purple	4-6	FACU	5.6-7.5
vervain, white	*Verbena urticifolia*	medium	4-9	june-aug	white	3-5	FACU	6.6-7.5
Virginia mountain mint	*Pycnanthemum virginianum*	very high	4-8	july-aug	white	1-3	FAC	5.0-7.5
wingstem	*Verbesina alternifolia*	high	4-6	july-sept	yellow	3-7	FAC	n/a

Appendix 2i. Wildflower Plant Characteristics for Pollinator and Conservation Plantings in the Northeast (continued)

Common Name	Light Needs	Vegetative Spread	Seedling Vigor	Persis-tence[6]	Seeds/lb	Cost (lb) ($)[3]	Ease of establishment plus other comments[4]
partridge pea	full to partial	none (an-nual plant)	high	low	65,000	14	a reseeding annual legume, seed at low rates, may be competitive during establishment
purple giant hyssop	full	n/a	n/a	low	1,488,000	80	attractive to bees, butterflies, and birds, RARE
senna, wild	full to partial	n/a	n/a	low	22,680	32	prairie communities, scarify seed
sneezeweed, common	full	none	high	medium	2,000,000	80	attracts butterflies, flowers late
spiderwort, Ohio	full to partial	n/a	n/a	low	128,000	160	
spiderwort, zigzag	partial	n/a	n/a	medium	130,000	54	bloom period fairly long
sunflower, ashy	full	high	n/a	high	125,000	180	will form dense stands, seed at low rate
sunflower, giant	full	none	n/a	medium	160000	280	large plant, small flowers
sunflower, oxeye (false)	full to partial	n/a	n/a	high	103,900	48	great wildlife plant, especially for birds
tick trefoil, showy	full to partial	n/a	n/a	medium	88,000	140	legume, *can become invasive*, seed low if used, velcro like seed pods, scarify seed
turtlehead	full-shade	slow	n/a	low	1,560,000	600	good for shady woods
vervain, blue	full to partial	n/a	n/a	low	1,544,000	54	insects eat leaves
vervain, hoary	full	slow	n/a	low	480,000	80	does not compete with vigorous grasses
vervain, white	full to partial	n/a	n/a	low	1,000,000	120	insects eat leaves
Virginia mountain mint	full to partial	slow	n/a	medium	3,840,000	480	very fragrant
wingstem	full to partial	n/a	n/a	low	239,000	140	threatened in NYS

[1] Not all plants are native to the Northeast region refer to the Natural Heritage Botantist and Nature Serve Explorer website http://www.natureserve.org/explorer/, for state specific information.

[2] Pollinator ranking is based on information provided by the Xerces Society.

[3] Cost estimates are on a bulk pound basis. Availability and prices may vary significantly year to year and by company. Get cost estimate before ordering.

[4] **Ease of establishment is color coded**: green performed- well, yellow- moderately well or slow to establish, red- poor establishment. This is preliminary information based on one location and two planting dates at the Big Flats PMC and 2 years of observations (2010 - 2011).

[5] n/a = information not currently available from the Plants Database.

[6] Persistence in field trial: high, medium and low.

Data for this table came from the following websites:

Xerces Society[2]
NRCS PLANTS database
www.wildflower.org
Michigan State University
Pollinator Partnership
CT Botanical Society
Native Plant Network
Nature Serve Explorer
Missouri Botanical Garden/Discover Life

Appendix 2j. Seeding Rate Calculator For Conservation Practices

												Seed tag information[1]					
Common name	Seeds/lb	bloom time	wetland indicator	$/ bulk lb[2]	lb PLS/ac	bulk lb/ ac	% of mix by PLS wt**	PLS seeds/ ac	PLS seeds/ ft²	% of mix by # of seeds/ ac	$ of each species/ ac	pure seed (%)	germ (%)	dormant + hard seed (%)	PLS (%)	Bulk Seed Needed (lb/A)	Cost of bulk seed/ ac
ashy sunflower	125,000	aug-sept	UPL	$180.00	0.25	0.25	0.042	31,250	0.72	0.017	45.00				100	0.25	45.00
gray-headed coneflower	625,000	july-aug	FAC	$48.00	0.25	0.25	0.042	156,250	3.59	0.087	12.00				100	0.25	12.00
early goldenrod	700,000	july-sept	UPL	$200.00	0.12	0.12	0.020	84,000	1.93	0.047	24.00				100	0.12	24.00
gray goldenrod	1,008,000	aug-oct	UPL	$240.00	0.05	0.05	0.008	50,400	1.16	0.028	12.00				100	0.05	12.00
hairy beardtongue	2,000,000	july-aug	FACU	$240.00	0.12	0.12	0.020	240,000	5.51	0.133	28.80				100	0.12	28.80
marsh blazing star	100,000	july-aug	FAC+	$200.00	0.3	0.30	0.050	30,000	0.69	0.017	60.00				100	0.30	60.00
new england aster	700,000	aug-oct	FACW	$220.00	0.2	0.20	0.033	140,000	3.21	0.078	44.00				100	0.20	44.00
partridge pea	65,000	june-aug	FACU	$14.00	1.0	1.00	0.167	65,000	1.49	0.036	14.00				100	1.00	14.00
purple coneflower	115,000	july-oct	FAC	$28.00	1.0	1.00	0.167	115,000	2.64	0.064	28.00				100	1.00	28.00
spotted beebalm	1,440,000	july-aug	UPL	$180.00	0.1	0.10	0.017	144,000	3.31	0.080	18.00				100	0.10	18.00
tall white beard tongue	400,000	may-july	FAC	$96.00	0.25	0.25	0.042	100,000	2.30	0.055	24.00				100	0.25	24.00
Virginia mountain mint	3,840,000	july-aug	FAC	$480.00	0.05	0.05	0.008	192,000	4.41	0.107	24.00				100	0.05	24.00
wild bergamot	1,200,000	june-july	UPL	$220.00	0.1	0.10	0.017	120,000	2.75	0.067	22.00				100	0.10	22.00
zigzag aster	700,000	july-sept	FAC	$180.00	0.21	0.21	0.035	147,000	3.37	0.082	37.80				100	0.21	37.80
canada wildrye	114,000	june-july	FACU+	$7.00	1.0	1.00	0.167	114,000	2.62	0.063	7.00				100	1.00	7.00
virginia wildrye	73,000	june-july	FACW-	$6.50	1.0	1.00	0.167	73,000	1.68	0.041	6.50				100	1.00	6.50
TOTAL FOR MIX BASED ON PLS					6.00				41.37								

lbs of PLS/Acre of Mix 6.00

lbs Bulk Seed/Acre 6.00

# of seeds per sq ft. 41.37

Total Price $407

**Please note that % of mix can be viewed as a "percent of mix by weight" or a "percent of mix by seeds per ft² basis" Which ever is most useful for the user.

[1] Default setting is for 100% PLS which is the same as bulk rate, assuming 100% germination and 100% purity. Entering your actual seed tag information will calculate actual bulk rate which will increase the amount and cost of the mix.

[2] Cost estimates are on a bulk pound basis. Cost per PLS will increase. Availability and prices may vary yearly and by company.

Note: Seed Calculator can be used for critical area and conservation seed mixes. Available on the Big Flats Plant Materials Website.

Appendix 2j (cont.). Pollinator Mixes Developed With Seeding Rate Calculator For Conservation Practices

Example Pollinator Dry Mix

Common Name	Bulk lb/ac	Bloom Time
ashy sunflower	0.25	aug-sept
gray-headed coneflower	0.25	july-aug
early goldenrod	0.12	july-sept
gray goldenrod	0.05	aug-oct
hairy beardtongue	0.12	july-aug
marsh blazing star	0.30	july-aug
New england aster	0.20	aug-oct
partridge pea	1.00	june-aug
purple coneflower	1.00	july-oct
spotted beebalm	0.10	july-aug
tall white beard tongue	0.25	may-july
Virginia mountain mint	0.05	july-aug
wild bergamot	0.10	june-july
zigzag aster	0.21	july-sept
Canada wildrye	1.00	june-july
Virginia wildrye	1.00	june-july
Total bulk lb/ac	6.00	
# of seeds per sq ft.	41.4	
Total Price	$407	

Example Pollinator Dry Mix

Common Name	Bulk lb/ac	Bloom Time
blue vervain	0.10	june-aug
boneset	0.20	july-sept
common sneezeweed	0.20	aug-sep
flat top white aster	0.20	july-sep
great blue lobelia	0.10	july-sept
New england aster	0.20	aug-oct
New York ironweed	0.20	aug-sept
rough goldenrod	0.15	aug-sept
spotted joe pye weed	0.20	july-oct
swamp milkweed	0.20	july-aug
marsh blazing star	0.20	july-aug
Alleghany monkey flower	0.02	july-aug
riverbank wildrye	2.00	june-july
Total bulk lb/ac	3.97	
# of seeds per sq ft.	82	
Total Price	$351	

Appendix 2k. Tree Characteristics for Planning Conservation Plantings

Common Name[1]	Genius Species	Flood Tolerance	Shade Tolerance	Soil Drainage	Drought Tolerance	pH	Growth Rate	20 year Growth (feet)
Softwoods (Conifers)								
Cedar, Atlantic White	*Chamaecyparis thyoides*	3	3	VP-W	R	4.0-6.3	M	20
Cedar, Eastern Red	*Juniperus virginiana*	2	1	SPD-EX	R	4.7-8.0	SL	25
Cedar, Northern White (Arborvitae)	*Thuja occidentalis*	4	3	P-W	R	6.0-8.0	M-F	25
Hemlock, Eastern	*Tsuga canadensis*	1	5	P-W	S	4.6-6.5	SL-M	22
Larch (All–Tamaracks)	*Larix laricina*	5	1	VP-SPD	R	4.8-7.5	F	30
Pine, Eastern White	*Pinus strobus*	2	3	SPD-W	S	4.5-6.5	M	30
Pine, Jack	*Pinus banksiana*	1	1	W-EX	R	4.6-6.5	F	50
Pine, Pitch	*Pinus rigida*	1	1	W-EX	R	4.6-6.5	F	50
Pine, Red	*Pinus resinosa*	2	3	SPD-EX	S/R	4.6-6.5	M	30
Spruce, Black	*Picea mariana*	5	4	VP-SPD	R	4.6-6.5	SL	20
Spruce, Norway[2]	*Picea abies*	2	2	SPD-W	S/R	5.0-7.0	M-F	35
Spruce, White	*Picea glauca*	4	4	SPD-W	S/R	6.0-7.9	SL-M	30
Hardwoods								
American Hornbeam	*Carpinus caroliniana*	2	5	P-EX	S	6.1-7.5	SL	18
American Linden	*Tilia americana*	2	4	MW-W	S	6.5-7.5	M	60
American Plum	*Prunus americana*	1	2	MW-EX	R	6.6-7.5	F	24
Ash, Black	*Fraxinus nigra*	5	2	VP-SPD	R	4.6-6.5	F	20
Ash, Green	*Fraxinus pennsylvanica*	4	2	SPD-W	R	6.1-7.5	F	35
Ash, White	*Fraxinus americana*	3	4	SPD-W	S/R	6.1-7.5	M	40
Birch, River	*Betula nigra*	4	2	P-MW	R	4.5-6.5	F	35
Birch, Yellow	*Betula lutea*	2	4	P-W	S	4.5-8.0	M	10
Blackgum	*Nyssa sylvatica*	3	2	P-W	R	6.1-6.5	SL	50
Butternut	*Juglans cinerea*	3	2	MW-W	S/R	6.6-8.0	F	20
Cherry, Black	*Prunus serotina*	1	2	MW-W	R	6.1-7.5	F	40
Cherry, Pin	*Prunus pensylvanica*	1	1	MW-EX	R	6.1-7.5	F	25

Source: Adapted from Hightshoe, G. L. (1987). Native Trees, Shrubs and Vines for Urban and Rural America. New York: Van Nostrand Reinhold and the PLANTS Database.

Appendix 2k. Tree Characteristics for Planning Conservation Plantings (continued)

Common Name[1]	Mature Height (feet)	Longevity (years)	Soil Compaction	Rooting Type	Density	Salt Tolerance	Deer Resistance	Plant Hardiness Zone
Softwoods (Conifers)								
Cedar, Atlantic White	60	>200	R	TAP	D	S/R	VP	4a
Cedar, Eastern Red	50-75	>200	S	TAP	D	R	P	3a
Cedar, Northern White (Arborvitae)	50-75	>200	S	SHL	D	S/R	VP	2
Hemlock, Eastern	75-100	>200	S	SHL	D	S	VP	3b
Larch (All–Tamaracks)	50-75	100-200	R	SHL	O	R	UP	2
Pine, Eastern White	75-100	>200	S	DPL	M	S	VP	3b
Pine, Jack	50-75	<100	S	DPL	O	R	P	2
Pine, Pitch	50-75	<100	R	TAP	O	R	P	5a
Pine, Red	75-100	>200	S	DPL	M	S	UP-P	2
Spruce, Black	50-75	100-200	R	SHL	D	S	UP	2
Spruce, Norway[2]	100	100-200	S/R	SHL	D	S/R-S	UP	3a
Spruce, White	50-75	>200	S/R	SHL	D	S	UP	2
Hardwoods								
American Hornbeam	35-50	100-200	S	DPL	D	S	P	2
American Linden	75-100	100-200	S	DPL	D	S	P	3a
American Plum	20-35	<100	S	SHL	D	R	P	3a
Ash, Black	50-75	<100	R	SHL	M	S/R	P	2
Ash, Green	50-75	100-200	R	SHL	M	S/R	P	2
Ash, White	75-100	100-200	S/R	SHL	M	S/R	P	3b
Birch, River	50-75	<100	R	SHL	O	S	P	4a
Birch, Yellow	50-75	100-200	S	DPL	M	S/R	VP	3a
Blackgum	50-75	100-200	S/R	TAP	D	R	P-UP	5a
Butternut	50-75	<100	S/R	TAP	O	S	P	3b
Cherry, Black	80	100-200	S	DPL/TAP	O	R	P	3b
Cherry, Pin	20-35	<100	S	DPL	O	R	P	2

Appendix 2k. Tree Characteristics for Planning Conservation Plantings (continued)

Common Name[1]	Genius Species	Flood Tolerance	Shade Tolerance	Soil Drainage	Drought Tolerance	pH	Growth Rate	20 year Growth (feet)
Hardwoods (continued)								
Hackberry (common)	*Celtis occidentalis*	3	3	SPD-W	R	6.6-8.0	M	26
Hawthorn, Cockspur	*Crataegus crusgalli*	3	2	SPD-EX	R	6.1-8.0	SL	30
Hawthorn, Dotted	*Crataegus punctata*	3	2	SPD-EX	R	6.1-8.0	SL	20
Hickory, Bitternut	*Carya cordiformis*	3	3	MP-W	S/R	5.6-8.0	SL	30
Hickory, Mockernut	*Carya tomentosa*	1	2	MW-EX	R	6.1-6.5	SL	18
Hickory, Pignut	*Carya glabra*	1	3	MW-W	R	6.1-7.5	SL	30
Hickory, Shagbark	*Carya ovata*	2	3	SPD-W	R	6.1-6.5	SL	15
Maple, Red	*Acer rubrum*	4	4	VP-W	R	4.5-6.5	M-F	35
Maple, Silver	*Acer saccharinum*	4	3	P-W	R	5.5-6.5	F	45
Maple, Sugar	*Acer saccharum*	2	5	MW-W	S	6.0-7.5	SL	20
Mulberry, Red	*Morus rubra*	3	3	P-W	R	6.3-8.0	F	45
Locust, Black	*Robinia pseudoacacia*	1	5	MW-EX	R	5.1-7.7	F	40
Locust, Honey	*Gleditsia triacanthos*	3	1	SPD-W	R	6.1-7.5	F	35
Oak, Black	*Quercus velutina*	1	3	MW-EX	R	6.1-6.5	M	25
Oak, Black Jack	*Quercus marilandica*	1	2	MW-EX	R	4.6-5.0	SL	20
Oak, Bur	*Quercus macrocarpa*	3	2	SPD-W	R	4.6-8.0	SL	25
Oak, Chestnut	*Quercus prinus (montana)*	2	3	SPD-W	R	6.1-6.5	SL	25
Oak, Chinkapin	*Quercus muhlenbergi*	1	2	W-EX	R	6.6-8.0	SL	30
Oak, Northern Red	*Quercus rubra (borealis)*	2	4	MW-W	S/R	4.8-6.5	M	36
Oak, Pin	*Quercus palustris*	4	2	P-W	R	5.5-6.5	M-F	40
Oak, Post	*Quercus stellata*	1	2	SPD-W	R	4.6-6.5	SL	25
Oak, Scarlet	*Quercus coccinea*	1	2	MW-W	R	6.1-6.5	M-F	30
Oak, Swamp White	*Quercus bicolor*	4	3	VP-SPD	R	6.0-6.5	M-F	30
Oak, White	*Quercus alba*	2	3	MW-EX	S/R	6.1-7.5	SL	25
Ohio Buckeye	*Aesculus glabra*	3	3	SPD-W	S/R	6.1-6.5	SL	25

Appendix 2k. Tree Characteristics for Planning Conservation Plantings (continued)

Common Name[1]	Mature Height (feet)	Longevity (years)	Soil Compaction	Rooting Type	Density	Salt Tolerance	Deer Resistance	Plant Hardiness Zone
Hardwoods (continued)								
Hackberry (common)	60-80	>200	S/R	DPL	M	R	UP	3a
Hawthorn, Cockspur	20-35	<100	S/R	TAP	D	R	UP	4b
Hawthorn, Dotted	20-35	<100	S/R	TAP	D	S	UP-P	4b
Hickory, Bitternut	75-100	>200	S/R	TAP	M	S	UP	4a
Hickory, Mockernut	75-100	>200	S	TAP	O	S	VP	4a
Hickory, Pignut	75-100	>200	S	TAP	O	S	P	4a
Hickory, Shagbark	75-100	>200	S/R	TAP	O	S	UP	4a
Maple, Red	75-100	100-200	R	SHL	M	S	P	3a
Maple, Silver	75-125	<100	R	SHL	O	S/R	VP	3b
Maple, Sugar	75-100	100-200	S	SHL	D	S	VP	3a
Mulberry, Red	60	<75	S/R	TAP	D	R	VP	4a
Locust, Black	75	50-75	S	SHL	O	R	P	3b
Locust, Honey	50-75	100-125	R	DPL/SHL	O	R	UP	4b
Oak, Black	75-100	100-200	S	DPL/TAP	M-O	S/R	VP	4b
Oak, Black Jack	35-50	>200	S	TAP	M-D	R	UP-P	5b
Oak, Bur	75-100	>200	S	TAP	O	R	P	2
Oak, Chestnut	50-75	>200	S	TAP	M-O	S/R	P	5a
Oak, Chinkapin	35-50	>200	S	DPL	O	S/R	VP	4b
Oak, Northern Red	81	>200	S	DPL	O	R	VP	3a
Oak, Pin	50-75	100-200	R	SHL	M	S	P	3b
Oak, Post	35-50	>200	S	TAP	O	S	VP	5b
Oak, Scarlet	50-75	>200	S	TAP	M	S	VP	5a
Oak, Swamp White	75-100	100-200	R	SHL	M	S/R	P	4a
Oak, White	75-100	>200	S	TAP	M	R	P	3a
Ohio Buckeye	35-50	100-200	S/R	TAP	M	S	UP	4a

Appendix 2k. Tree Characteristics for Planning Conservation Plantings (continued)

Common Name[1]	Genius Species	Flood Tolerance	Shade Tolerance	Soil Drainage	Drought Tolerance	pH	Growth Rate	20 year Growth (feet)
Hardwoods (continued)								
Persimmon	*Diospyros virginiana*	3	2	MW-W	R	6.1-6.5	SL	25
Poplar, Eastern Cottonwood	*Populus deltoides*	4	2	P-EX	R	6.6-7.5	F	80
Poplar, Hybrid[2]	*Populus deltoides x P. nigra*	3	1	SPD-W	S	6.6-7.5	F	40
Poplar, Yellow (Tulip Poplar)	*Liriodendron tulipifera*	1	3	MW-W	S	6.1-6.5	M-F	50
Sassafras, Common	*Sassafras albidum*	1	2	W-EX	R	6.0-6.5	M	24
Sumac, Smooth	*Rhus glabra*	2	1	MW-EX	R	6.1-7.0	F	12
Sumac, Staghorn	*Rhus typhina*	2	1	MW-EX	R	6.1-7.0	F	30
Sycamore, American	*Platanus occidentalis*	3	3	P-W	R	6.6-8.0	F	65
Walnut, Black	*Juglans nigra*	3	2	MW-W	R	6.6-8.0	F	25
Willow, Black	*Salix nigra*	5	1	VP-SPD	R	6.5-8.0	F	50

Appendix 2k. Tree Characteristics for Planning Conservation Plantings (continued)

Common Name[1]	Mature Height (feet)	Longevity (years)	Soil Compaction	Rooting Type	Density	Salt Tolerance	Deer Resistance	Plant Hardiness Zone
Hardwoods (continued)								
Persimmon	50-75	50-75	S/R	TAP	O	S/R	S	5a
Poplar, Eastern Cottonwood	75-100	<100	R	SHL	O	R	P	3b
Poplar, Hybrid[2]	60	<40	S	SHL	D	S	VP	3
Poplar, Yellow (Tulip Poplar)	75-100	100-200	S	SHL/DPL	M	S	VP	5a
Sassafras, Common	75	<100	R	TAP	O	R	VP	5a
Sumac, Smooth	20-35	<100	S	SHL	O	R	UP	2
Sumac, Staghorn	35-50	<100	S	SHL	O	R	VP	3a
Sycamore, American	75-100	>200	R	SHL	O	S	UP	4a
Walnut, Black	75-100	>200	S/R	TAP	O	S	P	4b
Willow, Black	35-50	<100	R	SHL	O	S/R	P	3a

[1] Not all plants are native to the entire Northeast region or may be rare, refer to the Natural Heritage Botantist and Nature Serve Explorer website http://www.natureserve.org/explorer/, for state specific information.

[2] Introduced specie in United States; use only when native alternatives are not available, check for invasive status.

*Avoid planting species with current insect pest or disease vulnerability.

Source: Adapted from Hightshoe, G. L. (1987). Native Trees, Shrubs and Vines for Urban and Rural America. New York: Van Nostrand Reinhold, and the PLANTS Database.

Legend for Tree Characteristics

Flood Tolerance: 1 = very intolerant, 2 = intolerant, 3 = intermediate, 4 = tolerant, 5 = very tolerant

Shade Tolerance: 1 = very intolerant, 2 = intolerant, 3 = intermediate, 4 = tolerant, 5 = very tolerant

Soil Drainage: VP = very poor, P = Poor, SPD = somewhat poorly drained, MW = moderately well, W = well, EX = excessively

Drought tolerance: S = sensitive, S/R = intermediate, R = resistant

pH: Is the preferred range from 4.0 to 8.5 where 4.0 is very acid and 8.5 very alkaline, for some species wider tolerance ranges are listed in the PLANTS Database

Growth Rate: SL = slow, M = medium, F = fast

Soil Compaction: S = sensitive, S/R = intermediate, R = resistant

Root Type: SHL = shallow lateral, DPL = deep lateral, TAP = taproot

Density: D = dense, M = moderate, O = open

Salt Tolerance: S = sensitive, S/R = intermediate, R = resistant (rated for road salt tolerance)

Deer Palatability: VP = very palatable, P = palatable, UP = unpalatable

Plant Hardiness Zone (minimum)

Refer to Figure 1a in Chapter 1.

2	3a	3b	4a	4b	5a	5b	6
-50 to -40°F	-40 to -35°F	-35 to -30°F	-30 to -25°F	-25 to -20°F	-20 to -15°F	-15 to -10°F	-10 to 0°F

Appendix 2I. Shrub Characteristics for Planning Conservation Plantings

Common Name[1]	Genius Species	Soil Drainage	Drought Resistant	Growth Rate	Longevity	Soil Compaction	Rooting Type
American Black Currant	*Ribes americanum*	VP-W	S/R	M	VSH	R	SHL
Alder, Smooth	*Alnus serrulata*	VP-W	R	F	SH	R	SHL
Alder, Speckled	*Alnus incana*	VP-W	S	M	MOD	R	SHL
American Cranberrybush	*Viburnum opulus*	P-W	S	M	SH	R	SHL
American Plum	*Prunus americana*	MW-EX	R	F	L	S	SHL
Allegany Blackberry	*Rubus allegheniensis*	MW-EX	R	F	VSH	S/R	SHF
Amorpha, Indigobush	*Amorpha fruticosa*	VP-EX	R	M/F	VSH	R	SHL
Amorpha, leadplant	*Amorpha canescens*	W-EX	R	M	VSH	S	SHL
Beach Plum	*Prunus maritima*	SPD-EX	R	M	L	S/R	SHL
Bearberry	*Arctostaphylos uva-ursi*	W-EX	R	SL	L	S	SHL
Blueberry, Highbush	*Vaccinium corymbosum*	VP-W	S/R	SL	SH	R	SHL
Blueberry, Lowbush	*Vaccinium angustifolium*	W-EX	R	SL	SH	S	SHL
Bog Rosemary	*Andromeda polifolia*	VP-SPD	S	SL	MOD	R	SHL
Black Huckleberry	*Gaylussacia baccata*	MW-EX	S/R	S	L	S/R	SHL
Bush Honeysuckle	*Diervilla lonicera*	MW-EX	R	F	VSH	R	SHL
Buttonbush	*Cephalanthus occidentalis*	VP-W	S	M	SH	R	SHL
Canada Yew	*Taxus canadensis*	MW-W	S	SL	L	S	TAP
Cherry, Pin	*Prunus pensylvanica*	MW-EX	R	F	MOD	S	DPL
Cherry, Sand	*Prunus pumila var. depressa*	SPD-EX	R	SL	L	S/R	TAP
Chinkapin	*Castanea pumila*	W-EX	R	M	SH	S/R	SHL
Chokeberry, Black	*Aronia melanocarpa*	VP-EX	R	SL	SH	R	SHL
Chokeberry, Purplefruit	*Aronia prunifolia*	VP-W	S/R	SL	SH	R	SHL
Chokeberry, Red	*Aronia arbutifolia*	VP-W	S/R	SL	SH	R	SHL
Cinquefoil, Bush	*Potentilla fruticosa*	P-EX	R	M	VSH	R	SHL
Common Juniper	*Juniperus communis*	W-EX	R	SL	L	S	TAP

Appendix 2l. Shrub Characteristics for Planning Conservation Plantings (continued)

Common Name[1]	Moisture Tolerance	pH	Disease	Insect	Density	Shade Tolerance	Mature Height (feet)	Salt Spray Tolerance	Plant Hardiness Zone
American Black Currant	W-AV	6.1-7.5	OC	OC	M	3	6	S	3a
Alder, Smooth	W-M	5.5-7.5	OC	OC	O	1	30	S	5a
Alder, Speckled	M	4.8-7.7	OC	OC	M	3	20	S	3a
American Cranberrybush	W-M	6.5-7.2	INFREQ	INFREQ	M	1	12	S	3b
American Plum	AV-VD	6.6-7.5	INFREQ	INFREQ	D	2	35	S/R	3a
Allegany Blackberry	AV-DR	4.5-7.5	OC	INFREQ	O	4	6	S	3b
Amorpha, Indigobush	W-VD	6.1-8.5	OC	OC	O	2	20	R	3a
Amorpha, leadplant	AV-VD	7.0-8.5	INFREQ	INFREQ	O	1	6	R	3a
Beach Plum	W-VD	5.8-7.7	INFREQ	INFREQ	M	1	12	S/R-S	3b
Bearberry	AV-VD	4.5-6.0	INFREQ	INFREQ	D	2	0.5	R	2
Blueberry, Highbush	W-DRY	3.5-6.0	OC	OC	D	4	12	R	4b
Blueberry, Lowbush	M-VD	4.0-6.0	OC	OC	O	4	1	R	2
Bog Rosemary	W-M	4.0-6.0	INFREQ	INFREQ	O	4	0.5	R	2
Black Huckleberry	W-M	4.5-6.5	INFREQ	INFREQ	D	4	4	S	3b
Bush Honeysuckle	AV-VD	6.1-6.5	INFREQ	OC	O	1	3	S	3a
Buttonbush	W-M	6.1-8.5	INFREQ	INFREQ	O	1	20	R	4a
Canada Yew	M	5.1-7.5	INFREQ	INFREQ	O	5	6	R	2
Cherry, Pin	M-AV	6.1-7.5	FREQ	FREQ	O	1	35	R	2
Cherry, Sand	AV-DRY	5.9-7.0	INFREQ	INFREQ	M-D	1	2	S	3a
Chinkapin	AV-VD	4.5-6.8	FREQ	INFREQ	D	3	25	S	5b
Chokeberry, Black	W-VD	5.1-6.5	INFREQ	INFREQ	M-O	3	6	R	3a
Chokeberry, Purplefruit	W-DRY	5.1-6.5	INFREQ	INFREQ	M	3	12	R	4a
Chokeberry, Red	W-DRY	5.1-6.5	INFREQ	INFREQ	M	3	12	R	4b
Cinquefoil, Bush	W-VD	5.0-8.5	INFREQ	INFREQ	D	1	4	R	2
Common Juniper	AV-VD	5.0-8.5	FREQ	OC	D	1	8	S/R	2

Appendix 2I. Shrub Characteristics for Planning Conservation Plantings (continued)

Common Name[1]	Genius Species	Soil Drainage	Drought Resistant	Growth Rate	Longevity	Soil Compaction	Rooting Type
Cranberry	*Vaccinium macrocarpon*	VP-SPD	S	SL	MOD	R	SHL
Dogwood, Alternate-leaf	*Cornus alternifolia*	SPD-W	S	SL	MOD	S/R	SHF
Dogwood, Flowering	*Cornus florida*	P-W	3	M	MOD	S	DPL
Dogwood, Gray	*Cornus racemosa*	MP-EX	R	M	SH	S/R	SHL
Dogwood, Redosier	*Cornus stolonifera*	VP-W	R	F	SH	R	SHL
Dogwood, Silky	*Cornus amomum*	VP-W	S/R	F	SH	R	SHL
Eastern Baccharis	*Baccharis halmifolia*	VP-EX	R	F	MOD	R	SHL
Elderberry	*Sambucus canadensis*	VP-EX	R	F	VSH	R	SHL/STO
Filbert, American (hazelnut)	*Corylus americana*	MW-EX	S/R	M/F	MOD	S/R	SHL
Filbert, Beaked	*Corylus cornuta*	MW-EX	S/R	M	MOD	S/R	SHL
Hawthorn, Cockspur	*Crataegus crusgalli*	SPD-W	R	SL	MOD	S/R	TAP
Hawthorn, Dotted	*Crataegus punctata*	SPD-W	R	SL	MOD	S/R	TAP
Hightide Bush, Marsh Elder	*Iva frutescens*	SPD-MW	S	M	L	S/R	SHL
Horn Beam	*Carpinus caroliniana*	P-W	S	SL	MOD	S	DPL
Inkberry	*Ilex glabra*	VP-W	S	SL	L	R	SHL
Leatherleaf	*Chamaedaphne calyculata*	VP-SPD	S	SL	SH	R	SHL
Low Birch	*Betula pumila*	VP-SPD	S/R	M/F	VSH	R	SHL
Maleberry	*Lyonia ligustrina*	VP-SPD	R	M	MOD	R	SHL
New Jersey Tea	*Ceanothus americanus*	W-EX	R	SL	VSH	S	SHL
Ninebark	*Physocarpus opulifolius*	VP-EX	R	F	MOD	R	SHL
Northern Bayberry	*Myrica pensylvanica*	VP-EX	R	M	MOD	R	DPL/SHL
Oak, Dwarf Chinkapin	*Quercus prinoides*	W-EX	R	SL	L	S	DPL
Oak, Scrub	*Quercus ilicifolia*	W-EX	R	M	L	S	DPL
Pasture Gooseberry	*Ribes cynosbati*	SPD-EX	R	M/F	VSH	S/R	SHL
Rose, Carolina	*Rosa carolina*	P-EX	R	F	SH	S/R	SHL
Rose, Prairie	*Rosa setigera*	SPD-EX	R	F	SH	S/R	SHL

Appendix 2l. Shrub Characteristics for Planning Conservation Plantings (continued)

Common Name[1]	Moisture Tolerance	pH	Disease	Insect	Density	Shade Tolerance	Mature Height (feet)	Salt Spray Tolerance	Plant Hardiness Zone
Cranberry	W	4.0-6.0	OC	OC	O	4	1	R	3a
Dogwood, Alternate-leaf	M-AV	4.8-7.3	INFREQ	INFREQ	O	5	25	S	2
Dogwood, Flowering	M-DRY	4.8-7.7	INFREQ	INFREQ	M	5	30	S	4a
Dogwood, Gray	M-VD	6.1-8.5	INFREQ	INFREQ	D	4	12	S	3a
Dogwood, Redosier	W-AV	6.1-8.5	OC	OC	M	1	12	S	2
Dogwood, Silky	W-AV	6.1-8.5	OC	INFREQ	M	4	12	S	4a
Eastern Baccharis	W-VD	7.0-8.5	INFREQ	INFREQ	O	1	12	R*	4a
Elderberry	W-DRY	6.1-7.5	OC	INFREQ	O	5	12	S	3a
Filbert, American (hazelnut)	M-VD	6.1-7.5	INFREQ	INFREQ	D	4	12	S	3a
Filbert, Beaked	M-VD	6.1-7.5	INFREQ	INFREQ	D	4	12	S	3a
Hawthorn, Cockspur	W-VD	6.1-8.0	FREQ	FREQ	VD	2	35	S	4b
Hawthorn, Dotted	W-AV	6.1-8.0	FREQ	FREQ	VD	2	35	S	4b
Hightide Bush, Marsh Elder	W-AV	5.0-7.5	INFREQ	INFREQ	D	1	9	R*	5b
Horn Beam	M-AV	6.1-7.5	INFREQ	INFREQ	VD	5	50	S	2
Inkberry	W-M	4.5-6.0	INFREQ	INFREQ	O	4	9	R*	4a
Leatherleaf	W-M	4.5-6.0	INFREQ	INFREQ	D	2	3	S/R-S	2
Low Birch	W-M	5.1-8.5	OC	FREQ	O	1	20	S/R	2
Maleberry	W-M	4.0-6.0	INFREQ	INFREQ	O	1	12	R	5b
New Jersey Tea	AV-VD	4.5-6.0	INFREQ	INFREQ	D	3	3	R	3b
Ninebark	W-VD	4.5-8.1	INFREQ	INFREQ	D	2	12	S/R	2
Northern Bayberry	W-VD	5.0-6.5	INFREQ	INFREQ	M	3	12	R*	4b
Oak, Dwarf Chinkapin	DRY-VD	5.1-8.5	OC	OC	O	2	12	R	5b
Oak, Scrub	DRY-VD	4.0-7.5	OC	OC	D	1	20	R	5b
Pasture Gooseberry	M-VD	6.1-8.5	OC	OC	D	5	6	S	2
Rose, Carolina	W-VD	6.1-8.5	OC	OC	D	2	4	R	4b
Rose, Prairie	M-VD	6.1-8.5	OC	OC	D	2	12	S	4b

Appendix 2I. Shrub Characteristics for Planning Conservation Plantings (continued)

Common Name[1]	Genius Species	Soil Drainage	Drought Resistant	Growth Rate	Longevity	Soil Compaction	Rooting Type
Rose, Rugosa[2]	*Rosa rugosa*	SPD-W	S/R	M	L	S/R	SHL
Rose, Swamp	*Rosa palustris*	SPD-MW	S	M	L	S/R	RHZ
Rose, Virginia	*Rosa virginiana*	M-W	R	M	MOD	S/R	SHL
Serviceberry, Allegany	*Amelanchier laevis*	W-MW	S	M	MOD	S	SHF
Serviceberry, Roundleaf	*Amelanchier sanguinea*	W-EX	R	M	SH	S	SHL
Serviceberry, Shadblow	*Amelanchier canadensis*	W-MW	S	M	MOD	S	SHF
Snowberry (common)	*Symphoricarpos albus*	MW-W	S/R	F	VSH	S/R	SHL
Spicebush (northern)	*Lindera benzoin*	MP-W	S	SL	MOD	S/R	DPL
Spirea, Hardhack	*Spirea tomentosa*	VP-SPD	R	F	VSH	R	SHL
Spirea, Meadowsweet	*Spiraea alba*	VP-SPD	R	F	VSH	R	SHL
Sumac, Fragrant	*Rhus aromatica*	W-EX	R	SL/M	SH	S	SHL
Sumac, Smooth	*Rhus glabra*	MW-EX	R	F	SH	S	SHL
Sumac, Staghorn	*Rhus typhina*	MW-EX	R	F	MOD	S	SHL
Sumac, Winged	*Rhus copallinum*	VP-SPD	R	M	MOD	R	SHL
Summersweet	*Clethra alnifolia*	VP-MW	S/R	SL/M	SH	R	SHL
Sweetfern	*Comptonia peregrina*	W-EX	R	SL	MOD	S	SHL
Viburnum[3], American Cranberrybush	*Virburnum opulus*	VP-W	R	M/L	MOD	R	SHL
Viburnum[3], Arrowwood	*Viburnum dentatum*	P-W	R	M	SH	S/R	SHL
Viburnum[3], Hobblebush	*Viburnum lantanoides*	MW-W	S	M	SH	S/R	SHL
Viburnum[3], Nannyberry	*Viburnum lentago*	SPD-W	S	SL	L	R	SHL
Viburnum[3], Mapleleaf	*Viburnum acerifolium*	SPD-W	S/R	SL/M	SH	S/R	SHL
Viburnum[3], Wild raisin	*Viburnum nudum*	VP-W	R	M	MOD	R	SHL
Viburnum[3], Witherod	*Viburnum cassinoides*	VP-W	S/R	M	MOD	R	SHL
Willow, 'Bankers' Dwarf [2]	*Salix x cottetii*	VP-MW	S	F	MOD	R	SHL
Willow, Bebbs	*Salix bebbianna*	VP-W	S	F	MOD	R	SHL

Appendix 2l. Shrub Characteristics for Planning Conservation Plantings (continued)

Common Name[1]	Moisture Tolerance	pH	Disease	Insect	Density	Shade Tolerance	Mature Height (feet)	Salt Spray Tolerance	Plant Hardiness Zone
Rose, Rugosa[2]	AV-DRY	5.5-7.5	OC	OC	D	1	5	R*	3b
Rose, Swamp	W-AV	4.0-7.0	FREQ	FREQ	O	5	8	R	3b
Rose, Virginia	M-AV	5.0-7.0	OC	OC	D	3	6	R	5a
Serviceberry, Allegany	M-AV	6.1-6.5	INFREQ	INFREQ	D	5	35	S	3a
Serviceberry, Roundleaf	AV-DRY	6.1-8.5	OC	OC	O	5	6	S	5a
Serviceberry, Shadblow	M-AV	6.1-6.5	INFREQ	INFREQ	D	5	45	R	3a
Snowberry (common)	M-DRY	6.1-8.5	FREQ	OC	D	2	6	R	2
Spicebush (northern)	W-AV	4.5-6.5	INFREQ	INFREQ	M	5	12	R	5a
Spirea, Hardhack	W-AV	5.1-6.0	OC	OC	O	2	6	S	4a
Spirea, Meadowsweet	W-M	6.6-7.5	OC	OC	D	2	6	S	3a
Sumac, Fragrant	AV-VD	6.1-8.5	OC	OC	D	1	12	R	4a
Sumac, Smooth	M-VD	6.1-7.0	INFREQ	INFREQ	O	1	20	R	2
Sumac, Staghorn	M-VD	6.1-7.0	INFREQ	INFREQ	O	1	50	R	3a
Sumac, Winged	W-VD	5.3-7.5	INFREQ	INFREQ	M	1	35	R	4a
Summersweet	W-M	4.5-6.5	INFREQ	INFREQ	O	4	12	R	4a
Sweetfern	DRY-VD	4.5-6.5	INFREQ	INFREQ	O	4	3	R	2
Viburnum[3], American Cranberrybush	W-AV	6.6-7.5	INFREQ	FREQ	D	5	16	S	2
Viburnum[3], Arrowwood	W-AV	5.1-6.5	INFREQ	FREQ	M-D	4	12	R	3a
Viburnum[3], Hobblebush	M-AV	5.5-6.5	OC	FREQ	O	5	12	S	3b
Viburnum[3], Nannyberry	W-AV	5.0-7.0	OC	FREQ	D	5	28	S/R-S	3b
Viburnum[3], Mapleleaf	M-DRY	5.1-6.0	OC	FREQ	D	5	6	S	3b
Viburnum[3], Wild raisin	W-AV	5.1-6.0	INFREQ	FREQ	M	4	20	S	6a
Viburnum[3], Witherod	W-DRY	5.1-6.5	INFREQ	FREQ	D	4	12	R*	2
Willow, 'Bankers' Dwarf [2]	W-M	5.5-7.5	INFREQ	INFREQ	D	3	5	S	4a
Willow, Bebbs	W-AV	5.5-7.5	INFREQ	INFREQ	M	1	35	R	2

Appendix 2l. Shrub Characteristics for Planning Conservation Plantings (continued)

Common Name[1]	Genius Species	Soil Drainage	Drought Resistant	Growth Rate	Longevity	Soil Compaction	Rooting Type
Willow, Heart Leaved	*Salix eriocephala*	MW-W	S	F	MOD	S/R	SHL
Willow, Prairie	*Salix humilis*	VP-EX	R	SL/M	SH	R	SHL
Willow, Pussy	*Salix discolor*	VP-SPD	R	SL	SH	R	SHL
Willow, Purple osier[2]	*Salix purpurea*	VP-W	S/R	F	L	S/R	SHL
Willow, Sandbar	*Salix exigua*	VP-W	S/R	F	MOD	S/R	SHL/RHZ
Willow, Shining	*Salix lucida*	VP-SPD	R	F	SH	R	SHL
Willow, Silky	*Salix sericea*	VP-W	S	F	MOD	R	SHL
Willow, Slender	*Salix petiolaris*	VP-W	S	F	MOD	R	SHL
Winterberry (common)	*Ilex verticillata*	VP-MW	S/R	SL	MOD	R	SHL
Witch Hazel	*Hamamelis virginiana*	VP-W	R	S	L	R	DPL

Appendix 2l. Shrub Characteristics for Planning Conservation Plantings (continued)

Common Name[1]	Moisture Tolerance	pH	Disease	Insect	Density	Shade Tolerance	Mature Height (feet)	Salt Spray Tolerance	Plant Hardiness Zone
Willow, Heart Leaved	W-AV	4.0-7.0	FREQ	FREQ	M	4	40	S	3a
Willow, Prairie	W-D	6.1-7.5	OC	OC	O	1	12	R	3a
Willow, Pussy	W-M	4.0-7.0	FREQ	FREQ	M	1	20	R	2
Willow, Purple osier[2]	W-DRY	5.5-7.5	OC	OC	D		16	S/R-S	3a
Willow, Sandbar	W-dry	6.0-8.5	OC	OC	D	3	16	S/R-S	3a
Willow, Shining	W-M	6.1-7.5	OC	OC	O	1	20	R	2
Willow, Silky	W-M	5.2-7.0	OC	OC	D	1	12	S	4a
Willow, Slender	W-M	5.2-7.0	OC	OC	M	3	10	R	2
Winterberry (common)	W-M	4.5-8.0	INFREQ	INFREQ	D	3	12	S	3b
Witch Hazel	W-DRY	4.5-7.0	INFREQ	INFREQ	D	4	18	S/R	4a

[1] Not all plants are native to the entire Northeast region or may be rare, refer to the Natural Heritage Botantist and Nature Serve Explorer website http://www.natureserve.org/explorer/, for state specific information.

[2] Introduced specie to United States; use only when native alternatives are not available, check for invasive status.

[3] For all viburnums, the viburnum leaf beetle can be a problem and should not be planted until this issue is resolved.

Adapted from Hightshoe, G. L. (1987). Native Trees, Shrubs and Vines for Urban and Rural America. New York: Van Nostrand Reinhold, 1987, and the PLANTS Database.

Legend for Shrub Characteristics

Soil Drainage: VP = very poor, P = Poor, SPD = somewhat poorly drained, MW=moderately well, W=well, EX = excessively well

Drought Resistant: R = resistant, S/R = intermediate, S = susceptible

Growth Rate: SL- slow, M = medium, F = fast

Longevity: VSH = very short, SH=short, MOD = moderate, L = long, VL = very long

Soil Compaction: R = resistant, S/R = intermediate, S = susceptible

Rooting Type: SHL = shallow lateral, SHF = shallow fibrous, DPL = deep lateral, TAP = taproot, STO = stoloniferous, RHZ = rhizomatous

Moisture Tolerance: W = wet, M = moist, AV = average, DRY = dry, VD = droughty

Disease: FREQ = frequently, OC = occasionally, INFREQ = infrequently

Insects: FREQ = frequently, OC = occasionally, INFREQ = infrequently

Density (Summer foliage): D = dense, M = moderate, O = open

Shade Tolerance: 1 = very intolerant, 2 = intolerant, 3 = intermediate, 4 = tolerant, 5 = very tolerant

Salt Tolerance: R = resistant, S/R = intermediate, S = susceptible (rated for road salt tolerance) R* = coastal application

Plant Hardiness Zone (minimum)

Refer to Figure 1a in Chapter 1.

2	3a	3b	4a	4b	5a	5b	6
-50 to -40°F	-40 to -35°F	-35 to -30°F	-30 to -25°F	-25 to -20°F	-20 to -15°F	-15 to -10°F	-10 to 0°F

Appendix 3a. Minimum Germination and Purity Requirements of Certified Seed

Common Name	Minimum Seed Purity (%)	Minimum Seed Germination[1,2] (%)
Cool-Season Grasses		
Alkali saltgrass	85	80
Barley	98	85
Bentgrass, Creeping	95	85
Bluegrass, Fowl	90	70
Bluegrass, Kentucky	97	80
Bluejoint, Canada	85	70
Bromegrass, Fringed	85	70
Bromegrass, Smooth	95	85
Cordgrass, Freshwater	85	70
Fescue: Creeping Red, Hard, Chewings, Sheep	97	85
Oats	98	85
Orchardgrass	90	80
Redtop	92	80
Rye, Cereal	98	85
Ryegrass: Annual or Perennial	97	85
Wheat	98	85
Wild Rye: Canada, Virginia, Riparian	85	70

Common Name	Minimum Seed Purity (%)	Minimum Seed Germination[1,2] (%)
Warm-Season Grasses		
Bluestem, Big	60	60
Little Bluestem, Broomsedge	55	60
Deertongue	95	75
Indiangrass	60	60
Millet, Foxtail	98	80
Switchgrass	95	75
Legumes/Forbs[3]		
Birdsfoot trefoil	98	95
Bush clover	80	50
Clover: Alsike, Red, Ladino	99	85
Flatpea	98	75
Flax	--	60
Lupine	--	65
Pea, Partridge	98	70
Tick trefoil	90	70

[1] Germination percentages required for certified seed may vary according to State Seed Laws.

[2] Germination includes the sum of germination, dormant and/or hard seed percentages.

[3] Seeds of kinds not listed in the minimum certification standards of the International Crop Improvement Association nor in the vegetable and flower seed standards set forth in State rules and regulations will be considered to be unfit for planting if they show no germination or distinctly weak vitality, or produce so few seedlings as to make a satisfactory stand in the field impossible at normal planting rates. Seeds of small-seeded legumes, forbs and all other seeds smaller in size than wheat, not listed in minimum standards will be considered to be unfit for planting if they contain noxious weed seeds at a rate of 100 seeds or more per pound.

Appendix 3b. Planting Equipment Calibration

Calibration of a drill or other planting equipment is an integral part of the seeding operation so that the recommended amount of seed is uniformly planted. If the equipment has not been used since the previous season, clean hoses by blowing out with compressed air to assure that there is no blockage from insects or rodent nests. To avoid problems with calibration and seeding, check all parts of the planter for need of repair or maintenance. Most seeders and spreaders will give recommended settings for different forage and grain crops which should be used as a starting point. Note that spinner type seeders do not distribute seed uniformly across the width of coverage and requires a planned overlap. When calibrating, it will usually require several attempts to achieve the desired seeding rate. Make adjustments to the drill and repeat procedures until seed weight is within 10 percent of the desired rate. Check results with one more trial at the same setting prior to seeding. There are other methods such as seed count methods which are not practical for most applications where the seed size is small. When calibrating, the distance of the test run used will depend on the size of the seed, the type of seeder and the accuracy of the scale used.

For all calibrations you must first calculate the bulk seeding rate for each species based on the pure live seed (PLS) of the seed lots being seeded as described in Chapter 3. For convenience the equation is:

PLS pounds per acre ÷ percent PLS = Bulk seeding rate per acre

For example: if 10 PLS pounds of seed is recommended and the seed lot has a PLS of 72 percent then the bulk seed will equal 13.9 pounds (10 ÷ 0.72 = 13.9 bulk pounds).

Drill calibration

For many seeding applications more than one hopper type will need to be used and calibrated due to differences in seed size. There are different methods used to calibrate a drill: (1) calibrating by the seed weight distance method by attaching bags to the drop tubes, traveling 100 feet, then collecting and weighing the seed; (2) determining the drive wheel circumference and turning it to simulate a distance of 100 feet, then calculate as in method 1. It is recommended to use a gram scale for these types of calibrations.

Method 1

Calibrating by the seed weight distance method. This method involves attaching bags to the drop tubes, traveling 100 feet or more, then collecting and weighing the seed. Next, determine the area covered from each drop unit and calculate pounds per acre needed from a drop unit. If not using a gram scale, increase the distance traveled to obtain enough seed for the accuracy of your scale. It is not necessary to collect the seed from every drop unit; at least two drop units from each side of the drill should be used. If drop units are not delivering a similar amount of seed, determine if cleaning or maintenance is needed.

To calculate pounds per acre needed from a drop unit using method 1:

1. Compute the area of a 100-foot test run in acres based upon the width of the drill to be used for the seeding then divide by the number of drop units.

Acreage of each drop unit = (drill width (ft) x travel distance (ft) ÷ 43,560 ft^2/ac) ÷ no. of drop units

For example with an 8-foot drill, 100-foot test run and 12 drop units the acreage per drop unit is:

8-foot drill x 100 ft ÷ 43,560 ft^2/ac ÷ (12 drop units) = .0015 acre per drop unit.

2. Calibrate the amount of seed per drop unit.

Amount of seed per drop unit = bulk lb/ac x acreage per drop unit or, Seeding Rate = Amount of seed collected (lb) ÷ area covered (ac).

Appendix 3b. Planting Equipment Calibration (continued)

For example, for a 20 bulk lb/ac seeding rate and .0015 acre per drop unit:

20 bulk lb/ac x .0015ac = .03 lb per drop unit needed.

To calculate the seeding rate, measure the seed collected in pounds and divide by the area covered in acres, for this example:

.03 lb/drop unit ÷ .0015 ac/drop unit = 20 lb/ac.

To convert to grams multiply the lb/drop unit by the conversion factor 454 grams/lb.

For example: .03 lb x 454 grams/lb = 13.6 grams. This is the weight needed per drop unit to obtain a 20 lb/ac seeding rate.

If you do not have a gram scale you can catch the seed in 4 drop units then visually evaluate for approximate equal volumes and weigh together and target 0.12 pound. Alternatively you could use a longer travel distance to catch a larger amount of seed and weigh each drop unit separately.

Method 2

Calibrating in place by drive wheel circumference method: involves lifting the drill up with a 3-point hitch, jacking it up if it is a towed model or, in some instances, disengaging a lock out on the drive wheel. Determine the circumference of the drive wheel from the manual or by measuring the circumference or by measuring the diameter and calculating the circumference (diameter x 3.14). Turn the drive wheel the required amount of turns to simulate a 100-foot travel distance. Individually collect the seed from 2 drop units from each side of the planter, calculate the amount of seed dropped and compare to the amount planned for. Using the example in Method 1, look for a weight of 13.6 grams for each unit.

Brillion Seeder

For a Brillion seeder you can build a catch unit out of card board to catch all of the seed. Travel 100 feet, weigh the seeds in pounds and determine the area covered in acres (100 ft x width of planter) ÷ 43,560 ft2/ac. Then calculate the pounds per acre by dividing pounds caught by the portion of the acre covered. The seed used can also be calculated by weighing the seed before and after the test run. A shop vacuum is used to remove the excess seed.

For example:
an 8-foot wide Brillion seeder traveling 100 feet; covers an area 100 ft x 8 ft ÷ 43,560 ft2/ac = .0184 acres.

If you want to seed 20 lb/ac you would want to catch 0.37 lb of seed calculated by:
20 lb/ac x .0184 ac = 0.37 lb. To convert to grams multiply by 454 g/lb conversion factor to obtain 168 grams.

To calculate the seeding rate, measure the seed collected in pounds and divide by the area covered in acres, for this example:

.37 lb ÷ .0184 ac = 20 lb/ac.

Spreader Calibration

Pendulum spreaders have calibration container attachments which can be used to catch the seed so that you can measure the amount of seed in a unit of time. Using the tractor, which will be used with the spreader, determine the gear and RPM necessary to operate the spreader and travel at a safe speed. At that speed determine the distance traveled in 30 seconds. Calculate the area by multiplying the distance traveled in feet by the spreader width pattern in feet, typically given in the manual for various seeds which considers an overlap. Determine the portion of an acre traveled by dividing the simulated area spread in square feet by the conversion factor 43,560

Appendix 3b. Planting Equipment Calibration (continued)

ft2/ac. Operate the pendulum spreader at the RPM used when determining the distance and area then collect the seed in a 30 second period. Weigh the seed in pounds and divide that amount by the portion of an acre spread to calculate the pounds per acre.

For example: if in 30 seconds you travel 176 feet (4mph) and the spreader width pattern was 20 feet then the area covered would be (176 x 20) ÷ 43,560 ft2/ac = .08 acres.

If you used 4 pounds of seed you were seeding at the rate of 4/.08 = 50 pounds per acre.

Note: (176 ft ÷ 5,280 ft/mi) ÷ (30 sec ÷ 3,600 sec/hr) = 4 mph.

To improve coverage it is recommended to divide the seed and rate in half and plan on spreading the seed in two separate passes perpendicular to each other. If you do not have the calibration container attachment then follow the procedure outlined below for the spinner type spreaders.

Spinner type spreaders will have to be calibrated as you go by: (1) filling the hopper with a given amount of seed; (2) spreading the seed in a predetermined area by measuring the linear distance traveled and multiplying by the spreader width pattern given in the manual or measure the width spread considering an overlap; (3) removing the remainder of the seed with a shop-vac and; (4) reweighing the remainder of the seed from the shop-vac and subtracting from the original quantity to determine the amount of seed used. Avoid letting the seed get too low in the hopper since that will affect the calibration. As a starting point use the setting from the Spreader Manual.

To determine the area spread use the same method as with the pendulum calibration; multiplying the distance traveled by the spreader pattern. If you traveled 176 feet and the spreading pattern was 20 feet then (176 x 20) ÷ 43,560 ft2/ac = .08 acres.

If 4 pounds of seed was used, divide by the area spread (.08) acres to determine pounds per acre. If you spread seed over .08 acres and you used 4 pounds of seed you were seeding at the rate of 4/.08 = 50 pounds per acre. It may take a few times to adjust the setting to the rate needed. To improve coverage it is recommended to divide the seed and rate in half and plan on spreading the seed in two separate passes perpendicular to each other.

Appendix 3c. Northeast Shrubs Suitable for Soil Bioengineering Systems

Common Name	Genus/Species	Habitat[1]	Plant Hardiness Zone[2]	Bank Zone[3]	Plant Material Form[4]
Smooth alder	*Alnus serrulata*	nontidal	4 to 7	toe	seedling
False indigo	*Amorpha fruticosa*	Nontidal, tidal fresh	4 to 7	lower-mid	rooted unrooted
Chokeberry, red	*Aronia arbutifolia*	nontidal	4 to 7	lower-mid	seedling
Chokeberry, Black	*Aronia melanocarpa*	nontidal	4 to 7	mid-upper	seedling
Groundsel bush	*Baccharis halimifolia*	tidal, tidal fresh	6 to 7	mid-upper	rooted, (unrooted)
Buttonbush	*Cephalanthus occidentalis*	nontidal, tidal fresh	3b to 7	toe	rooted, (unrooted)
Sweet pepperbush	*Celthra alnifolia*	tidal, tidal fresh	6 to 7	mid-upper	rooted
Dogwood, silky 'indigo'	*Cornus amomum*	streambanks, pond edges	4 to 7	lower-mid	rooted, (unrooted)
Dogwood, gray	*Cornus racemosa*	streambanks, pond edges	2 to 7	lower-mid	seedling
Dogwood, redosier 'Ruby'	*Corus serecia*	streambanks, pond edges	2 to 7	toe-mid	rooted unrooted
Possum haw	*Ilex decidua*	forested wetlands, pond edges	6 to 7	lower-mid	rooted
Inkberry	*Ilex glabra*	forested wetlands, sandy woods	4 to 7	mid-upper	rooted
Winterberry holly	*Ilex verticillata*	tidal fresh, forested wetlands	3b to 7	lower-mid	rooted
Virginia sweetspire	*Itea virginica*	forested wetlands, streambanks	6 to 7	toe	rooted
Hightide bush	*Iva frutescens*	tidal brackish	6 to 7	lower	rooted, (unrooted)
Leucothoe/swamp doghobble	*Leucothoe/Eubotrys racemosa*	forested wetland, moist woods	6 to 7	lower-mid	seedling
Spicebush	*Lindera benzoin*	seasonal wetlands, floodplain	5 to 7	lower-mid	rooted
Maleberry	*Lyonia ligustrina*	open woods	5 to 7	lower-mid	rooted
Sweetbay magnolia	*Magnolia virginiana*	stream borders, for wetland	6 to 7	lower-mid	rooted
Wax myrtle	*Myrica cerifera*	tidal fresh, brackish swales	6 to 7	mid-upper	rooted
Bayberry	*Morella pensylvanica*	tidal fresh, brackish nontidal	4b to 7	mid-upper	seedling
Ninebark	*Physocarpus opulifolius*	streamsides, wood edges	3 to 7	low-mid	rooted unrooted
Cherry, dwarf sand 'Catskill'	*Prunus pumila var. depressa*	streamside, sandbars	3b to 7	mid-upper	rooted
Swamp azalea	*Rhododendron viscosum*	forested wetland	5b to 7	toe-low	rooted

Appendix 3c. Northeast Shrubs Suitable for Soil Bioengineering Systems (continued)

Common Name	Shade Tolerance[5]	Flood Tolerance[6]	pH range	Comments
Smooth alder	medium	regular	5.5-7.5	Nitrogen fixer, weak wooded
False indigo	low	seasonal	5.9-8.5	Requires full sun, drought tolerant
Chokeberry, red	medium	irregular-seasonal	5.1-6.5	Drought tolerant
Chokeberry, Black	low	irregular-seasonal	5.1-6.5	Drought tolerant
Groundsel bush	high	seasonal	7.0-8.5	Male/Female separate plants
Buttonbush	high	permanent	6.0-8.5	Tolerates some drought
Sweet pepperbush	high	seasonal	4.5-6.5	Some salt tolerance, drought tolerant
Dogwood, silky 'indigo'	medium	seasonal	5.5-8.5	Drought tolerant
Dogwood, gray	high	seasonal	5.5-8-5	Drought tolerant
Dogwood, redosier 'Ruby'	medium	regular-seasonal	5.5-8.5	Drought tolerant
Possum haw	high	irregular	4.0-6.0	Male/Female separate plants
Inkberry	high	irregular	4.5-6.0	Male/Female separate plants plants, resists salt spray
Winterberry holly	high	seasonal	4.5-8.0	Drought tolerant
Virginia sweetspire	high	regular	5.0-7.0	Some salt tolerance
Hightide bush	low	regular	6.0-7.5	Highly tolerant of salt, to 15 ppt salt, seawater is 35 ppt
Leucothoe/swamp doghobble	high	regular	5.0-6.0	Tolerates some drought
Spicebush	high	seasonal	4.5-6.5	Tolerates some drought
Maleberry	low	seasonal	4.0-6.0	Acid tolerant
Sweetbay magnolia	high	irregular-seasonal	4.0-6.5	Some salt tolerance
Wax myrtle	high	regular	4.0-6.0	Highly tolerant of salt to 10 ppt salt. N-fixing
Bayberry	high	irregular-seasonal	5.0-6.5	Tolerates drought, N-fixing
Ninebark	medium	seasonal	4.5-8.1	
Cherry, dwarf sand 'Catskill'	low	irregular-seasonal	5.5-8.5	Drought tolerant
Swamp azalea	medium	regular-seasonal	4.0-6.0	Susceptible to disease

Appendix 3c. Northeast Shrubs Suitable for Soil Bioengineering Systems (continued)

Common Name	Genus/Species	Habitat[1]	Plant Hardiness Zone[2]	Bank Zone[3]	Plant Material Form[4]
Swamp rose	*Rosa palustris*	tidal fresh for wetland streambank	3b to 7	toe-low	rooted
Staghorn/Smooth sumac	*Rhus typhina/glabra*	disturbed banks/ dry sites	3b to 7	upper	rooted
Willow, dwarf 'Bankers'	*Salix X cottetii*	streambank	4 to 7	toe-mid	unrooted, rooted
Willow, pussy	*Salix discolor*	streambank forested wetland	3b to 7	toe-mid	unrooted, rooted
Willow sandbar, 'Greenbank'	*Salix exigua*	streambank sandbars	3 to 7	toe	unrooted, rooted
Willow purpleosier, 'Streamco'	*Salix purpurea*	streambank	3b to 7	toe-upper	unrooted, rooted
Elderberry	*Sambucus canadensis*	tidal fresh, nontidal, wet meadow	3 to 7	low-mid	rooted unrooted
Meadowsweet	*Spirea alba/tomentosa*	forested wetland	4 to 7	mid-upper	rooted
Viburnum, Southern arrowwood	*Viburnum dentatum*	tidal fresh, nontidal, forest wetland	3 to 7	mid-upper	rooted, (unrooted)
Viburnum, Nannyberry	*Vibrurnum lentago*	forested wetland	4 to 7	mid-upper	rooted, (unrooted)
Viburnum, blackhaw	*Viburnum prunifolium*	forested wetland	5 to 7	upper	rooted, (unrooted)
Viburnum, American cranberrybush	*Viburnum trilobum*	forested wetland	2 to 7	lower-mid	rooted, (unrooted)

Appendix 3c. Northeast Shrubs Suitable for Soil Bioengineering Systems (continued)

Common Name	Shade Tolerance[5]	Flood Tolerance[6]	pH range	Comments
Swamp rose	low	seasonal-regular	4.0-7.0	Prefers full sun
Staghorn/Smooth sumac	low	irregular	6.1-7.0	Tolerates some drought
Willow, dwarf 'Bankers'	medium	regular-permanent	5.0-7.5	Introduced male hybrid
Willow, pussy	medium	regular-permanent	5.0-7.5	Attractive landscaping plant
Willow sandbar, 'Greenbank'	low	regular-permanent	5.0-7.5	Aggressive root suckering, some salt tolerance
Willow purpleosier, 'Streamco'	medium	regular-permanent	6.0-7.0	Introduced male hybrid
Elderberry	high	irregular-seasonal	5.5-8.0	Some salt tolerance, drought tolerant
Meadowsweet	low	irregular	5.1-6.0	Drought tolerant
Viburnum, Southern arrowwood	medium	seasonal	5.1-7.0	Drought tolerant
Viburnum, Nannyberry	medium	seasonal	6.0-7.0	Forms dense thickets
Viburnum, blackhaw	medium	irregular	4.8-7.5	
Viburnum, American cranberrybush	low	irregular-seasonal	5.5-7.5	Drought tolerant

[1] Habitat is the natural environmental site conditions where the plant is found:
Nontidal - freshwater ponds, lakes, streams, and rivers not tidally influenced
Tidal fresh - upper reaches of tidally influenced rivers and streams where salinity is extremely low ranging from 0.5 ppt -1 ppt
Brackish - occurs in salinities ranging from 1 ppt-15 ppt
Streambanks - freshwater streams
Forested wetlands - freshwater wetlands occurring in a forest understory

[2] Plant Hardiness zone: is referenced from 2 to 7

[3] Bank Zone: Recommended planting location on the bank slope: toe, low, mid, upper

[4] Plant Material Form:
rooted – a bare root (1-0 or 2-0) seedling or containerized
unrooted – good to excellent rooting from a dormant hardwood cutting
(unrooted) – fair to poor success from a dormant hardwood cutting

[5] Shade Tolerance: The relative value in relation to other species. A shade tolerant species may prefer partial shade to full sun

[6] Flood Tolerance:
Permanent to semipermanent: tolerates inundation or saturation from 76% - 100% of the growing season
Regularly: tolerates in inundation or saturation from 26% - 75% of the growing season
Seasonally: tolerates inundation or saturation from 13% - 25% of the growing season
Irregularly: tolerates inundation or saturation from 5% - 12% of the growing season

Appendix 4a. Seeding and Planting Dates by Plant Hardiness Zone and Plant Type

	Plant Hardiness Zones				
Plant Type	**3**	**4**	**5**	**6**	**7**
Cool Season Grass spring	4/25—6/20	4/15—6/10	4/1—6/1	3/20—5/20	3/10—5/10
Cool Season Grass fall[1]	8/1—8/20	8/5—9/1	8/10—9/5	8/20—10/1	9/1—10/15
Warm Season Grass-spring[2]	No later than 6/1	No later than 6/10	No later than 6/15	No later than 5/25[2]	No later than 5/10[2]
Warm Season Grass-dormant[3]	after 10/21	After 10/21	After 10/25	After 11/15	After 12/1
Bare Root Deciduous-spring[4]	To 6/10	To 6/1	To 5/15	To 5/1	To 4/15
Bare Root Deciduous-fall	9/25—11/1	10/5—11/5	10/15—11/15	10/25—11/25	11/5—12/5
Bare Root Conifers-spring[4]	To 6/10	To 6/1	To 5/15	To 5/1	To 4/15
Bare Root Conifers-fall[5]	9/25—10/15	10/5—10/25	10/15—11/15	10/25—11/15	11/5—11/25
Containerized or B&B Deciduous-spring[6]	To 6/15	To 6/15	To 6/1	To 5/15	To 5/1
Containerized or B&B[7] Deciduous-fall	8/1—10/15	8/5—10/20	8/15—11/1	9/1—11/10	9/1—11/25
Containerized or B&B Conifers-spring[6]	To 6/15	To 6/15	To 6/1	To 5/15	To 5/1
Containerized or B&B Conifers-fall[8]	8/1—10/15	8/1—10/20	8/1—11/1	8/15—11/1	8/15—11/15
Soil Bioengineering-dormant[9]	10/15—6/15	10/20—6/10	11/1—6/5	11/15—5/15	11/25—4/30
American Beachgrass Culms-dormant	NA	NA	11/1—4/15	11/15—4/15	11/25—4/1

[1] When legumes are planted in late summer with grasses, seed around 1 week prior to the earliest date listed if there is adequate soil moisture. Grasses can be seeded earlier if there is adequate soil moisture or irrigation.

[2] Later planting dates of warm season grasses especially on well drained soils risk failure due to summer heat and drought. Seedings are sometimes conducted after these dates to allow for spraying early emerging weeds.

[3] Due to excessive soil moisture in fall, site and soil workability may not be feasible, increase seeding rates by 40% when dormant seeding.

[4] Dormant stock preferred, plan on watering toward the end or past this period or if dormancy is broken prior to planting.

[5] It is best to plant bare root conifers in the spring since fall planted conifers are vulnerable to winter desiccation on soils that will be frozen in the root zone. If planting in the fall, plant as early as feasible.

[6] Plan on watering toward the end or past this period and if dormancy is broken prior to planting.

[7] Some decidous species do better if fall planted in containers. If planted B&B it is best if the plant was dug the previous spring and appropriately held over in the nursery prior to fall planting than if dug in the fall just prior to planting.

[8] Conifers are best planted in the spring due to being prone to winter injury. If planted in the fall they should be planted earlier with adequate watering and not planted after date indicated to allow for adequate root growth going into winter. Consider anti-desiccants or other wind protection when planting on droughty soils or toward the end of the planting date range.

[9] Later portion of date range assumes adequate cooler storage and may require irrigation. For streambank projects plant following spring runoff. For upland plantings fall planting is acceptable but very early spring planting is preferable on sites with adequate moisture.

Appendix 4b: Temporary Seeding for Site Stabilization

Common Name Cereal Grains[1]	Seeding Rate lbs/ac	Seeding Rate lbs/1000ft²	Seeding Depth (inches)	lbs/bu	Seeds/lb[(2)]	Recommended Seeding Dates by Plant Hardiness Zone[3] 3 & 4	5	6 & 7a
Oats	96	2.2	3/4 to 1	32	16,900	Apr 1 to July 1 Aug 1 to Sept 1	Mar 15 to Jun 15 Aug 1 to Sept 15	Mar 1 to Jun 1 Aug 15 to Sept 30
Barley[4]	96	2.2	3/4 to 1	48	13,600	Apr 1 to July 1 Aug 1 to Sept 10	Mar 15 to Jun 15 Aug 1 to Sept 20	Mar 1 to Jun 1 Aug 5 to Oct 20
Wheat[5]	120	2.8	3/4 to 1	60	18,800	Aug 1 to Sept 20	Aug 1 to Oct 1	Aug 15 to Oct 30
Cereal Rye	112	2.6	3/4 to 1	56	19,900	Aug 1 to Sept 25	Aug 1 to Oct 5	Aug 15 to Oct 30

Common Name Temporary Grasses	Seeding Rate lbs/ac	Seeding Rate lbs/1000ft²	Seeding Depth (inches)	Seeds/lb[(2)]	Recommended Seeding Dates by Plant Hardiness Zone[3] 3 & 4	5	6 & 7a
Annual Ryegrass	40	1	1/8 to 1/2	240,400	Apr 1 to May 31 Aug 1 to Sept 1	Mar 15 to May 31 Aug 1 to Sept 15	Mar 1 to May 31 Aug 15 to Sept 30
Perennial Ryegrass	40	1	1/8 to 1/2	217,000	Apr 1 to May 31 Aug 1 to Sept 1	Mar 15 to May 31 Aug 1 to Sept 15	Mar 1 to May 31 Aug 15 to Sept 30
Foxtail Millet (Setaria italica)	30	0.7	1/8 to 1/2	216,600	June 1 to July 15	May 15 to July 15	May 1 to Aug 5
Sorghum-sudangrass[6]	40	1	1/4 to 3/4	28,000	June 1 to July 15	May 15 to July 15	May 1 to Aug 5

[1] Reduce cereal grain seeding rate by 1/2 if used as a nurse crop for cool season grasses. Increase seeding rate 1/3 if seeding alone toward end of range. For winter grains the last 2 weeks of the range extends only for zone 7a.

[2] Wide variability in reported seeds per pound.

[3] Seeding dates are based on PHZ averages, timing will vary based on location within zones, elevation, aspect and slope position. Mid summer dates subject to drought conditions.

[4] Use disease resistant varieties, use spring barley for the spring dates and winter hardy barley varieties for the late summer dates, barley is less winter hardy than wheat.

[5] If concerned about spreading Hessian fly to nearby wheat fields, do not plant until after Hessian fly-free date. Consult with Cooperative Extension, consider triticale or rye for earlier or later planting.

[6] Used for smother cropping prior to conservation planting will need one mowing if planted early.

Appendix 4c. Recommended Permanent Seeding Mixtures by Purpose

Purpose of the Planting	Recommended Seed Mixes (1-25) from Appendix 4d																									Comments
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
Roadsides, Steep Slopes		X	X		X	*	X				*	*	*	*	*			*	*	*			*			
Sand and Gravel Pits, Sanitary Landfills (droughty soils)		X	*	X	X							*	X	X				*								Use cool season mixes only when fines exceed 20%
Mineland, Dredged Material, Spoil Banks, Greensands/ Glauconitic soils (acid soils)					X		X		*	*	X	X	X	X					X				*			For low pH acid soils
Logging & Haul Roads,	*		X	*	X	*		*							X	X										Short lived, shade tolerant species
Utility Rights of Way					X		X				*	*			*											
Dikes, Dams, Ponds	*		X	*	X	*	X																			prefer mow tolerant grasses
Berms, Low Embankments (not on Ponds), Channelbanks	*		X	*	X	X	X	*	*	*	*	*		*	X			*								
Riparian areas	*		*	*	X	*		X	X		X	*	*	*	X	*		*								Consider native mixes for areas not prone to high velocity flows
Grassed Waterways, Diversions, Terraces, Spillways, Streambanks	*	X	*		X	X	X																			
Bottom of Drainage Ditches, Swales, Detention Basins					X			X		*																Use 8 for native, 5b if not, for salt concerns use 10
Cover for Orchards, Christmas trees & Woody buffers	*	X	X	X										X				X								
Coastal plantings (Dunes, Shorelines)																					*	X	X	X	X	Use 24 only for the Great Lakes not coastal
Recreation areas, Low maintenance areas/turf	X	X	X	X	*	*		*																		
Salt-affected areas								*		X									X	X	X					Use salt tolerant varieties
High Elevation, ski slopes																	X									Use short season hardy varities

X - Recommended mix for this purpose; * - Alternative mix, depending on site conditions

Appendix 4d. Seed Mixes and Associated Soil Drainage Class and Shade Tolerance

Seed Mixture[1]	Rate[2] (lb/acre)	Seeds/lb	Species Seeds/ ft²	Seed Mix Total Seeds/ft² choice a.	Seed Mix Total Seeds/ft² choice b.	Pure Live Seed (PLS)[3]	Soil Drainage Class of mix[4]	Shade Tolerance of mix[5]	Comments
Low maintenance turf-like mixes and erosion control (mowing) (non-native species)									
1. KY bluegrass	15	1,389,840	479				w-mw	g-f	Increase ratio of red fescue to Kentucky bluegrass and add hard fescue for shadier sites. For conventional lawns higher rates are used follow turf grass recommendations from Cooperative Extension.
Creeping red fescue	15	454,087	156						
Perennial ryegrass	5	240,400	28	663					
White clover (optional)	4	711,867	65		700				
2. Creeping red fescue	15	454,087	156				w-swp	g-f	On swp drained sites increase ratio of tall fescue to red fescue and use redtop.
Tall fescue (turf-type)	15	205,720	71						
a. Perennial ryegrass or	5	240,400	28	255					
b. Redtop	2	4,851,200	223		450				
White clover (optional)	4	711,867	65	320	515				
3. Creeping Red fescue	20	454,087	208				w-mw	g-f	For mix without tall fescue and there is concern for erosion.
Perennial ryegrass	5	240,400	28						
Redtop	2	4,851,200	223	459					
White clover (optional)	4	711,867	65		524				
4. Hard fescue	15	591,920	204				w-mw	g	Low growing mix, use at 1/3 rate or lower with wildflowers, add 10 lb/ac of sheep fescue on gravel areas.
Chewings fescue	15	350,000	121						
Creeping red fescue	15	454,087	156						
Perennial ryegrass (turf type)	5	240,400	28	508					
Waterways and general erosion control									
5a. Creeping red fescue	15	454,087	156				w-mw	p	In areas with variable drainage use redtop and add 15 lb/ac of tall fescue.
Smooth bromegrass	15	142,880	49						
a. Redtop or	2	4,851,200	223	428					
b. Perennial ryegrass	5	240,400	28		233				
Birdsfoot trefoil (optional)[6]	8	369,840	68	496	301				

Appendix 4d. Seed Mixes and Associated Soil Drainage Class and Shade Tolerance (continued)

Seed Mixture[1]	Rate[2] (lb/acre)	Seeds/lb	Species Seeds/ ft²	Seed Mix Total Seeds/ft² choice a.	Seed Mix Total Seeds/ft² choice b.	Pure Live Seed (PLS)[3]	Soil Drainage Class of mix[4]	Shade Tolerance of mix[5]	Comments
Waterways and general erosion control (continued)									
5b. Creeping red fescue	15	454,087	156				w-swp	p	Most commonly used mix on conservation structures.
Tall fescue[7]	15	205,720	71						
a. Redtop or	2	4,851,200	223	450					
b. Perennial ryegrass	5	240,400	28		255				
Birdsfoot trefoil (optional)	8	369,840	68	518	323				
6. KY bluegrass	15	205,720	71				w-mw	f	Use this mixture in areas which are mowed frequently.
Creeping red fescue	15	454,087	156						
Redtop	2	4,851,200	223						
Perennial ryegrass	5	240,400	28						
a. Birdsfoot trefoil or	8	369,840	68	545					
b. White clover	4	711,867	65		543				
7. Tall Fescue	30	205,720	142				w-swp	f	Use when high water velocities are expected. Produces a dense sod which can restrict volunteer vegetation. Good for utility right of ways. Tall fescue endophyte free and friendly forage varieites are available.
Perennial ryegrass	5	240,400	28	169					
Wet areas (native)									
8. Virginia wildrye	15	100,000	34				swp-p		In areas where erosion is a concern increase fowl bluegrass and autumn bentgrass by an additional 2 lb each, this may outcompete other species in the mix.
Riparian wildrye	15	125,000	43						
Fringed brome	5	236,000	27						
Fox sedge	2	1,297,000	60						
Fowl bluegrass[8]	2	1,900,000	87						
Autumn bentgrass[9]	1	8,000,000	184	435					
Carex scoparia (Optional)	0.5	1,312,000	15	450					

Appendix 4d. Seed Mixes and Associated Soil Drainage Class and Shade Tolerance (continued)

Seed Mixture[1]	Rate[2] (lb/acre)	Seeds/lb	Species Seeds/ ft²	Seed Mix Total Seeds/ft² choice a.	Seed Mix Total Seeds/ft² choice b.	Pure Live Seed (PLS)[3]	Soil Drainage Class of mix[4]	Shade Tolerance of mix[5]	Comments
Wet areas (native) (continued)									
9. Deertongue	3	350,000	24			pls			Use 'Hightide' switchgrass PHZ 5- north and use 'Kanlow' PHZ 6- south, If erosion is concern add fowl bluegrass, not for waterways or drainage ditches.
Switchgrass	3	259,000	18			pls	w-p	f-p	
Riparian wildrye	5	125,000	14						
Prairie cordgrass	1	638,863	15	71		pls			
Fowl bluegrass (optional)	1	1,900,000	44	115					
Wet, saline sites (roadside ditches)									
10. Alkali saltgrass	10	520,000	119				mw-swp	f	Use salt resistant turfgrass cultivars, for drier areas exclude alkali saltgrass.
Tall fescue (turf)	10	205,720	47						
Perennial ryegrass (turf)	5	240,400	28						
Creeping red fescue (turf)	10	454,087	104	298					
Warm season grass base mix									
11. Deertongue	3	350,000	24			pls	mw-swp	f-p	Use prairie cordgrass on swp drained sites. If erosion is a concern increase Virginia wildrye to 10 lb/ac. Eastern gamagrass should be seeded at least 1 inch deep.
Switchgrass	3	259,000	18			pls			
Eastern gamagrass	2	7,200	0.3			pls			
Virginia wildrye	5	100,000	11	54					
Prairie cordgrass (optional)	1	638,863	15	68		pls			
12. Switchgrass	2	259,000	12			pls	w-mw	p	On drier sites substitute Canada wildrye. If erosion is a concern increase wildrye to 10 lb/ac.
Big bluestem	3	144,240	10			pls			
Indiangrass	2	174,720	8			pls			
Deertongue	2	350,000	16			pls			
Virginia wildrye	5	100,000	11	57					
Eastern gamagrass (optional)	2	7,200	0.3	58		pls			

Appendix 4d. Seed Mixes and Associated Soil Drainage Class and Shade Tolerance (continued)

Seed Mixture[1]	Rate[2] (lb/acre)	Seeds/lb	Species Seeds/ ft²	Seed Mix Total Seeds/ft²		Pure Live Seed (PLS)[3]	Soil Drainage Class of mix[4]	Shade Tolerance of mix[5]	Comments
				choice a.	choice b.				
Droughty areas (sand and gravels)									
13. Switchgrass	2	259,000	12			pls	ex	p	Increase each of the other warm season grass by 1lb/ac if dropping optional species.
Coastal panicgrass	2	325,000	15			pls			
Big bluestem	2	144,240	7			pls			
Little bluestem	1	240,670	6			pls			
Canada wildrye	5	114,000	13	52					
Sand lovegrass (optional)	2	1,625,680	75	127		pls			
Sand bluestem (optional)	2	96,640	4	131		pls			
Short native mix									
14. Little bluestem	4	240,670	22			pls	ex-mw	p	Short native mix, for wildflowers reduce deertongue by 1/2. Use purpletop zone PHZ6 and south.
Purpletop	2	465,000	21			pls			
Canada wildrye	5	114,000	13						
Deertongue	2	350,000	16	73		pls			
Sideoats grama (optional)	3	159,200	11	84		pls			
Native cool season grasses (shaded sites, log landings)									
15. Virginia wildrye	5	100,000	11				w-swp	g	For erosion control increase autumn bentgrass and fowl bluegrass to 2 lb/ac, and increase wildryes to 10 lb/ac. For swp drained sites substitute riparian wildrye for Canada wildrye.
Canada wildrye	5	114,000	13						
Fringed brome	5	236,000	27						
Autumn bentgrass	1	8,000,000	184						
Fowl bluegrass	1	1,600,000	37	272					

Appendix 4d. Seed Mixes and Associated Soil Drainage Class and Shade Tolerance (continued)

Seed Mixture[1]	Rate[2] (lb/acre)	Seeds/lb	Species Seeds/ ft²	Seed Mix Total Seeds/ft² choice a.	Seed Mix Total Seeds/ft² choice b.	Pure Live Seed (PLS)[3]	Soil Drainage Class of mix[4]	Shade Tolerance of mix[5]	Comments
Haul road/log landing mix with wildlife value, no woody plant suppression									
16. Orchardgrass	5	427,200	49				w-swp	g	Temporary cover allows for natural succession
Timothy	6	1,163,200	160						
Creeping red fescue	3	454,087	31						
Redtop	1	4,851,200	111						
Ladino clover	1	860,000	20						
Red clover	2	272,160	12						
Alsike clover	2	680,400	31	415					
High elevation mix (2,500 ft. and higher, PHZ 5 and colder)									
17. Hard fescue	10	591,920	136				w-swp	p	Mix for erosion control in colder areas.
Chewings fescue	10	645,000	148						
Creeping red fescue	10	454,087	104						
Redtop	1	4,851,200	111						
White clover	2	711,867	33	532					
Birdsfoot trefoil (optional)	6	369,840	51	583					
Cover for Christmas trees, orchards, and woody buffers									
18. Hard fescue	15	591,920	204				w-mw	g	
Creeping red fescue	4	454,087	42						
Perennial ryegrass	3	240,400	17						
White clover	2	711,867	33	295					

Appendix 4d. Seed Mixes and Associated Soil Drainage Class and Shade Tolerance (continued)

Seed Mixture[1]	Rate[2] (lb/acre)	Seeds/lb	Species Seeds/ ft²	Seed Mix Total Seeds/ft²		Pure Live Seed (PLS)[3]	Soil Drainage Class of mix[4]	Shade Tolerance of mix[5]	Comments
				choice a.	choice b.				
Dredge disposal sites									
19. Alkali saltgrass	2	520,000	24				ex-mw	p	
Switchgrass	3	259,000	18			pls			
Coastal Panicgrass	5	325,000	37			pls			
Deertongue	5	350,000	40			pls			
Canada wildrye	10	114,000	26						
Autumn bentgrass	1	8,000,000	184	329					
Partridge pea (optional)	4	65,000	6	335					
Alkaline soil conditions									
20. Alkali saltgrass	5	520,000	60				w-mw	f	
Canada wildrye	5	114,000	13						Use barley as nurse crop if needed at 30 lb/ac.
Hard fescue	10	591,920	136						
Sideoats grama or	3	159,200	11	220		pls			
Little bluestem	3	240,670	17		236	pls			
Dry, saline (coastal sites)									
21. Coastal panicgrass	5	325,000	37			pls	ex	p	
Switchgrass	5	259,000	30			pls			
Partridge pea	2	65,000	3	70					
Back dune plantings									
22. Coastal panicgrass	10	325,000	75	75		pls	ex	p	
American beachgrass	12″-18″								American beachgrass and saltmeadow cordgrass are vegetatively planted.
Saltmeadow cordgrass	12″-18″								

Appendix 4d. Seed Mixes and Associated Soil Drainage Class and Shade Tolerance (continued)

Seed Mixture[1]	Rate[2] (lb/acre)	Seeds/lb	Species Seeds/ ft²	Seed Mix Total Seeds/ft² choice a.	Seed Mix Total Seeds/ft² choice b.	Pure Live Seed (PLS)[3]	Soil Drainage Class of mix[4]	Shade Tolerance of mix[5]	Comments
ATLANTIC COAST-VEGETATIVE PLANTINGS (Vegetative)									
Foredunes, blowing sand areas									
23. American beachgrass	12-18″ centers						ex	p	Relatively fast to establish cultivar 'Cape' available. Do not use around Great Lakes and lake Champlain.
Great Lakes, Lake Champlain									
24. American beachgrass	12-18″ centers						ex	p	Slow to establish allows for natural revegetation, use local ecotypes for Great Lakes and Lake Champlain.
Tidal shoreline planting									
25. Smooth cordgrass	12″-18″							P	Smooth cordrass intertidal zone, saltmeadow cordgrass above mean high water.
Saltmeadow cordgrass	12-18″ centers							p	

[1] For information on varieties refer to discussion in Chapter 3. When available, It is a good practice to use more than one cultivar or ecotype of the species being sown for better diversity and adaptability. Refer to Appendix 2f, for a list of available cultivars and ecotypes of warm season grasses.

[2] To convert from lb/ac to lb/1000ft² (lb/ac x.023 = lb/1000ft²).

[3] Pure Live Seed is indicated for warm season grasses and their seeds per pound and seeds per square foot are calculated in PLS.

[4] Soil drainage classes: ex = excessively drained, w = well drained, mw = moderately well drained, swp = somewhat poorly drained, p = poorly drained.

[5] Shade tolerance: g = good, f = fair, p = poor.

[6] In lieu of birdsfoot trefoil substitute with 4 lb/ac of white clover on w to mw soils or alsike clover on swp soils.

[7] Tall fescue forage types have endophyte free and friendly cultivars, most turf varieties have endophyte.

[8] High rates of fowl bluegrass in all mixes can crowd out other species in mix.

[9] High rates of agrostis species in all mixes can crowd out other species in mix. Agrostis scabra can be substituted, in part, for diversity

Appendix 4e. Guide to Mulch Materials, Rates, and Uses

Application Rates

Mulch Materials	Quality Standards	Per 1000 sq. ft.	Per Acre	Depth of Application	Remarks
Straw or Hay	Air-dried, free of undesirable seeds and coarse materials	90 - 100 lbs 2 - 3 bales	2 tons, 100 - 120 bales	Cover about 90% of surface	Use straw where mulch is maintained for more than three months. Subject to wind blowing unless anchored. This is the most commonly used mulching material. Best micro environment for germinating seeds. Do not use mulch hay in areas where weed seeds are a concern, use straw.
Wood chips or shavings	Green or air dried, free from objectionable coarse materials	6 - 21 yd^3		2 – 7 in.	It is best to use composted wood chips, typically used as a mulch around ornamentals, small fruits and other nursery stock. Do not incorporate into the soil to avoid nitrogen deficiency during the breakdown of the organic matter and/or use 10 - 12 lb nitrogen/ton to offset the nitrogen deficiency. Resistant to wind blowing and decomposes slowly. Higher amounts in range are used when not planting. 1 ft3 weighs approximately 18 lbs. Use on slopes less than 15%.
Sawdust green, or composted	Free from objectionable coarse material	3 - 18 yd^3		1 - 5 in.	Has about the same use and nitrogen deficiency concerns as wood chips. May require 30 - 35 lbs nitrogen/ton to offset potential nitrogen deficiency. 1 ft3 weighs approximately 36 - 52 lbs.
Hydraulic mulches: wood fiber, cellulose, bonded fiber matrix and mechanically bonded fiber matrix	Dyed green, air-dried 30%, fibers 3.7 mm or longer	30 lbs	1500 - 4000 lbs		Many products exist which includes cellulose, wood fiber, combination of the two and those which combine natural and synthetic materials. Apply at rates according to Manufacturer's specifications based on slope and other site characteristics. Tackifiers are usually needed to hold mulch on site.
Leaves	No plastic bags, or household debris	375 - 700 lbs	8 - 15 tons	3 - 6 in.	Leaves should be shreaded and kept dry prior to use so they do not compost.
Cornstalks, shredded or chopped	Air-dried, shredded into 8 in. to 12 in. lengths	150 - 300 lbs	4 - 6 tons		Effective for erosion control, relatively slow to decompose. Resistant to wind blowing.

Appendix 4e. Guide to Mulch Materials, Rates, and Uses

Application Rates

Mulch Materials	Quality Standards	Per 1000 sq. ft.	Per Acre	Depth of Application	Remarks
Grass clippings	Unbagged, free of debris, minimal odor	700 - 1400 lbs	15 - 30 tons	1 - 2 in.	Obtain necessary permits. Must be spread within 24 hours of delivery. Observe buffer requirements. Incorporate with next tillage season for crop establishment.
Peat Moss	Dried, compressed free of coarse materials	200 ft^3	1/2 - 1 ton	2 - 4 in.	Most effective as a mulch around ornamentals. Subject to wind blowing unless kept wet. Bales weigh 6 - 8 lb/ft^3. Excellent moisture holding capacity.
Gravel, Crushed Stone or Slag	Washed; Size 2B or 3A, 1.5 in.	9 yds^3	-----	3 in.	Excellent mulch for short slopes and around woody plants and ornamentals. Use 2B when subject to foot traffic. Frequently used over black plastic for better weed control.
Jute Twisted Yarn	Undyed, unbleached plain, warp 78 per 4 ft width, Weft 42/yd length, 1.25 to 1.8 lb/yd	48 in. x 75 yds			Use without additional mulch. Tie down as in manufacturing specification. Can be used on slopes greater than 2:1 if used with fiber mulch.
Excelsior Wood Fiber Mats	Interlocking web of excelsior fibers with photodegradable plastic netting on one or both sides	Variable length based on product, 4 - 16 ft wide.			Use without additional mulch. Excellent for seed establishment. Tie down as per manufacturer specifications. Approximately 78 lbs/roll for excelsior with plastic on both sides. Use two sided plastic for centerline of waterways. Many new erosion control blanket products are available.
Plastic	4 - 6 mils	Variable			Use black for weed control. Effective moisture conservation and weed control for small fruits ornamentals.
Filter Fabrics	Woven or Spun	Variable			
Straw or coconut fiber or combination	Photodegradable plastic net on one or two sides.	Variable			Designed to tolerate higher velocity water flow in centerlines of waterways.

Appendix 4f. Mulch Anchoring Guide Specification Sheet

Anchoring Method or Material	Kind of Mulch to be Anchored	How to Apply
A. Manual		
1. Peg and twine	Hay or straw	After mulching, divide areas into blocks approx. 1 yd2. Drive 4 to 6 pegs per block to within 2 to 3 inches of soil surface. Secure mulch to surface by stretching twine between pegs in criss-cross pattern on each block. Secure twine around each peg with 2 or more turns. Drive pegs flush with soil where mowing and maintenance is planned.
2. Mulch netting	Hay or straw	Staple the light-weight paper, jute, wood fiber, or plastic nettings to soil surface according to manufacturer's recommendations. Should be biodegradable. Most products are not suitable for foot traffic.
3. Soil & Stones	Plastic	Plow a single furrow along edge of area to be covered with plastic, fold about 6 inches of plastic into the furrow and plow furrow slice back over plastic. Use stones to hold plastic down in other places as needed.
4. Cut-in	Hay or straw	Cut mulch into soil surface with square edged spade. Make cuts in contour rows spaced 18 inches apart. Most successful on contour in sandy soils.
B. Mechanical		
1. Wood cellulose fiber	Hay or straw	Apply with hydroseeder immediately after mulching. Use 500 to 750 pounds of wood fiber mulch per acre. Some products contain an adhesive material.
2. Pick chain	Hay or straw manure compost	Use on slopes steeper than 3:1. Pull across slopes with suitable power equipment.
3. Mulch anchoring tool, Mulch crimper	Hay or straw, manure/mostly straw	Set in straight position and pull across slope with suitable power equipment. Mulch material should be "tucked" into soil surface about 3 inches. Do not cut the straw.
4. Chemical	Hay or straw	There are many companies and products to choose from. Typically an anionic polyacrylamide tackifier with at least 200 lb/ac of fiber mulch is used. There are also organic materials such as guar gum, plantago and starches. Consult with manufacturer's specifications and representatives for the particular application.

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A guide to

Conservation Plantings

on Critical Areas for the Northeast

This guide covers some factors to consider when planning and implementing critical area seedings and conservation plantings. It discusses the differences between critical area stabilization, conservation plantings and restoration with an emphasis on critical area stabilization. The use of native species, diversity and the concern for the spread of invasive species is emphasized. It points out the importance of soils and building and maintaining soil quality as and integral part of all conservation plantings. It addresses the need for other measures to control erosion where needed to withstand high velocities of water and to divert water to facilitate successful seedings. It stresses mulching as an integral part of most critical area seedings and plantings. The guide is divided into sections based on the steps in conducting conservation plantings starting with planning, selecting plant material, purchasing plant materials to installing the seeding or planting, and not by plant type.