3

Vegetative Considerations

3

Vegetative Considerations

EFFECTS OF VEGETATION ON EROSION, SEDIMENTATION, AND PROPERTY VALUE

Dense, vigorous vegetation protects the soil surface from raindrop impact, a major force in dislodging soil particles and moving them downslope. It also shields the soil surface from the scouring effect of overland flow and decreases the erosive capacity of the flowing water by reducing its velocity.

The shielding effect of a plant canopy is augmented by roots and rhizomes that hold the soil, improve its physical condition, and increase the rate of infiltration, further decreasing runoff. Plants also reduce the moisture content of the soil through transpiration, thus increasing its capacity to absorb water (Figure 3.1)

Suitable vegetative cover affords excellent erosion protection and sedimentation control and is essential to the design and stabilization of many structural erosion control devices. Vegetative cover is relatively inexpensive to achieve and tends to be self-healing; it is often the only practical, long-term solution to stabilization and erosion control on most disturbed sites in North Carolina.

Planning from the start for vegetative stabilization reduces its cost, minimizes maintenance and repair, and makes structural erosion control measures more effective and less costly to maintain. Post-construction landscaping is also less costly where soils have not been eroded, slopes are not too steep, and weeds are not allowed to proliferate. Natural areas—those left undisturbed—can provide low-maintenance landscaping, shade, and screening. Large trees increase property value if they are properly protected during construction.

Besides preventing erosion, healthy vegetative cover provides a stable land surface that absorbs rainfall, cuts down on heat reflectance and dust, restricts weed growth, and complements architecture. The result is a pleasant environment for employees, tenants and customers, and an attractive site for homes. Property values can be increased dramatically by small investments in erosion control. Even the final landscaping represents only a small fraction of total construction costs and contributes greatly to the marketing potential of a development.

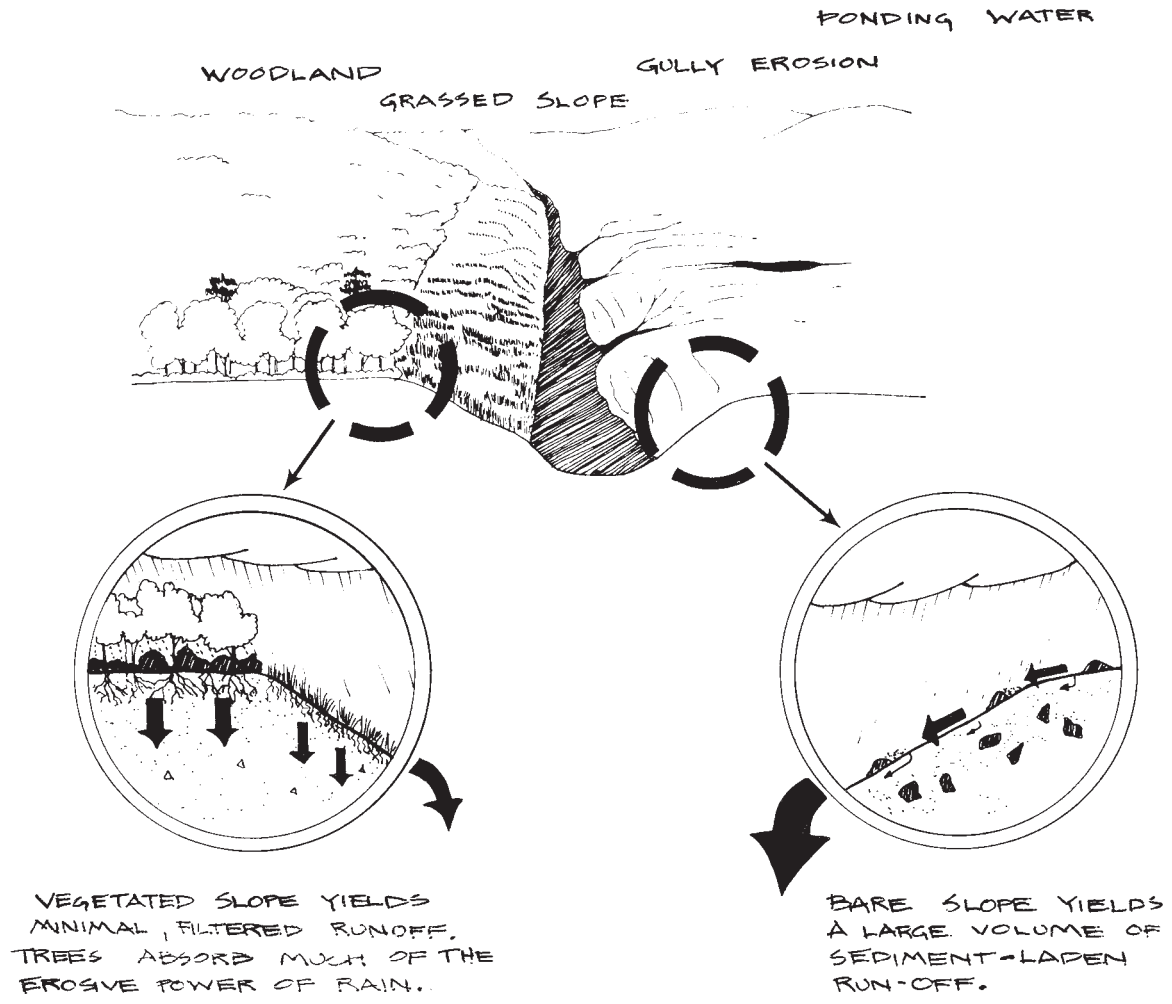

Figure 3.1 Effects of vegetation on erosion.

SITE CONSIDERATIONS

Species selection, establishment methods, and maintenance procedures should be based on site characteristics including soils, slope, aspect, climate, and expected management.

Slope

The steeper the slope, the more essential is a vigorous vegetative cover. Good establishment practices, including seedbed preparation, quality seed, lime, fertilizer, mulching and tacking are critical. The degree of slope may limit the equipment that can be used in seedbed preparation, planting, and maintenance; steep slopes also increase costs.

Aspect

Aspect affects soil temperature and available moisture. South-and west-facing slopes tend to be warmer and drier, and often require special treatment. For example, mulch is essential to retain moisture, and drought-tolerant plant

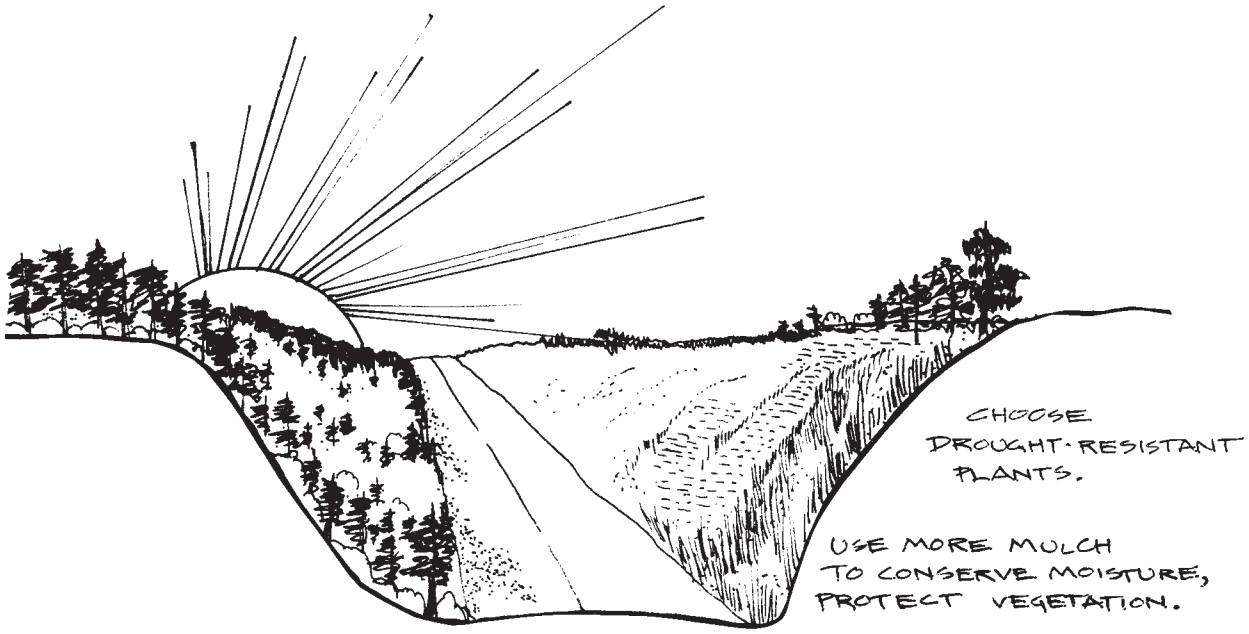

Figure 3.2 South- and west-facing slopes are hot and dry.

species should be added to the seed mixture (Figure 3.2). South- and west-facing slopes also may be subject to more frost heaving due to repeated cycles of freezing and thawing.

Climate

The regional climate must be considered in selecting well-adapted plant species. North Carolina recommendations are usually based on three broad physiographic regions: Mountain, Piedmont, and Coastal Plain. Climatic differences determine the appropriate plant selections based on such factors as cold-hardiness, tolerance to high temperatures and high humidity, and resistance to disease.

Management

When selecting plant species for stabilization, consider post-construction land use and the expected level of maintenance. In every case, future site management is an important factor in plant selection.

Where a neat appearance is desired, use plants that respond well to frequent mowing and other types of intensive maintenance. Likely choices for quality turf in the west are tall fescue, Kentucky bluegrass, and Bermudagrass, or in the east, Bermudagrass, centipedegrass, zoysiagrass, and Bahiagrass.

At sites where low maintenance is desired, longevity is particularly important. Sericea lespedeza, tall fescue, annual lespedeza, and, in some cases, Bermudagrass, redtop, or crownvetch are likely choices. Other species may be appropriate to intermediate levels of maintenance.

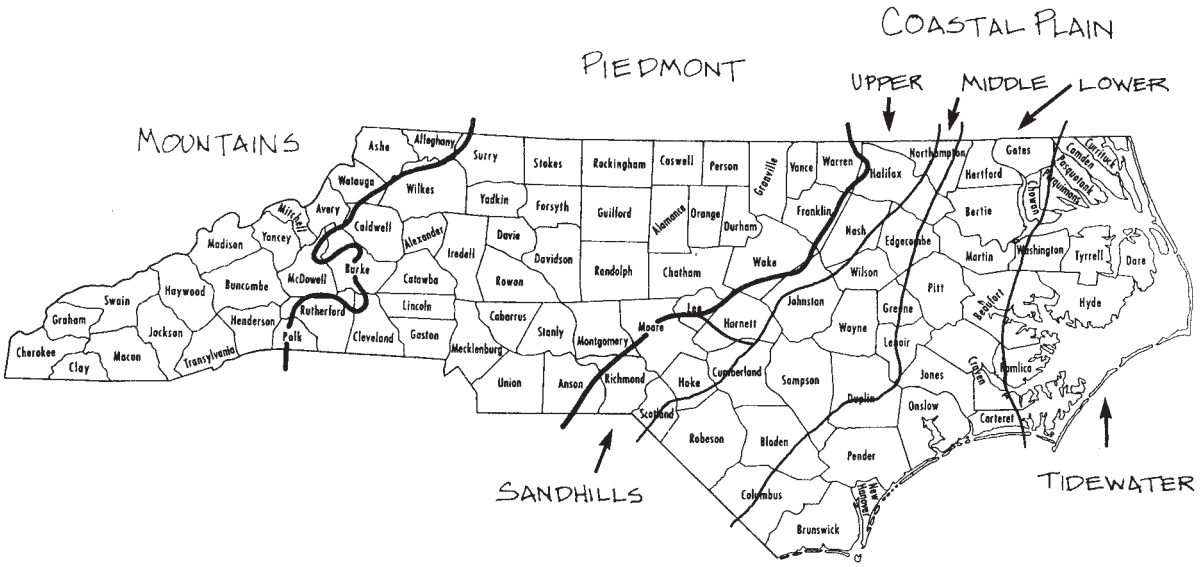

Figure 3.3 Major physiographic regions of North Carolina differ in relief, geology, climate, elevation, and major soil systems.

Soils

Many soil characteristics— including texture, organic matter, fertility, acidity, moisture retention, drainage, and slope—influence the selection of plants and the steps required for their establishment. The following is a very general description of North Carolina soils with respect to characteristics that affect stabilization of disturbed sites. Soil formation in North Carolina has been influenced primarily by parent materials and relief. As a result, soils differ among the major physiographic regions shown in Figure 3.3.

Mountain Region

Surface soils of the Mountain Region vary from sandy loam to clay loam, with shallow subsoils varying from silt loams to sandy loams. Steep slopes with shallow, stony, droughty soils are common. Many mountain soils have been severely eroded. On more level topography, deeper profiles provide greater water-storage capacity and room for root growth. Shallow, stony soils and steep slopes present major problems for vegetation establishment in this region. Permanent vegetation is normally selected from cool-season, winter-hardy perennials.

Piedmont Region

Piedmont soils are similar to those of the Mountains but, in general, are deeper, lower in organic matter, and have subsoils higher in clay. Deeper subsoils are typically silts, silt loams, and sandy loams. Surface soils vary from sandy loam to clay loam, and subsoils are commonly thick with heavy clay texture. While topography is gentler than in the Mountains, it is mostly rolling to hilly, with well-developed drainage patterns. Soils are generally well to excessively drained.

The sloping terrain and silty subsoils often result in severe erosion potential. As a result of previously poor management practices, many areas are moderately to severely eroded.

Piedmont soils generally support a wide variety of plants, including both cool- and warm-season species. Sites that are steep, shallow, stony, droughty, or severely eroded present problems for establishment of vegetation.

Coastal Plain Region

Coastal Plain soils include some of the easiest and some of the most difficult soils to vegetate. The Coastal Plain region has several different subregions to consider.

The Sand Hills region of the Coastal Plain is dominated by coarse, deep, excessively drained sand and rolling topography. These soils are extremely low in organic matter and plant nutrients. When disturbed, they are subject to both wind and water erosion. These are some of the most erodible soils in the State and need to be treated with the utmost caution. Due to their low water-holding capacity, revegetation requires highly drought-resistant species.

Upper and Middle Coastal Plain soils generally have well-drained sandy loam surface horizons underlain by sandy clay loam subsoils. Topography is undulating to nearly level. These soils retain more moisture and nutrients than the sands of the Sand Hills and coastal dunes, and support a wider variety of vegetation. However, they are still quite erodible when disturbed. The region also includes some poorly drained soils and some excessively drained "Sand Hills" soils.

Lower Coastal Plain soils vary from well-drained to poorly drained and from sand to silt loam in texture. The coarser soils are extremely erodible. Poorly drained soils ranging from sands to organics are limited in extent. Along the southern coast both old and young dune sands occur. Choice of species for revegetation is largely determined by moisture retention and drainage conditions. Dune sands require a unique group of species.

The Tidewater Region is dissected by sounds and numerous wide rivers. Soils may be wet and mostly organic or mineral soils with high clay content. Draining these soils can be difficult. The organic mucks and peats are most often underlain by sand, but may have silt or clay subsoils.

Nature of Disturbed Soils

Throughout the State, most disturbed sites end up, after grading, with a surface consisting of acid, infertile subsoil materials that are toxic to most plants (Figure 3.4). Such soils may not be capable of supporting the dense growth necessary to prevent erosion. Construction activities further decrease soil productivity by increasing compaction, making slopes steeper, and altering drainage patterns. Topsoiling, soil amendments, and special seedbed preparation are generally required to offset these problems.

Soil Sampling

A good sedimentation control plan should include thorough soil sampling in the area of planned construction. Different soils should be sampled separately. Containers for soil samples and instructions for sampling may be obtained from any local Agricultural Extension office or from the North Carolina Department of Agriculture. Analysis of soil samples is available from the NCDA soil testing lab. Test results include lime and fertilizer recommendations. Fertilizing

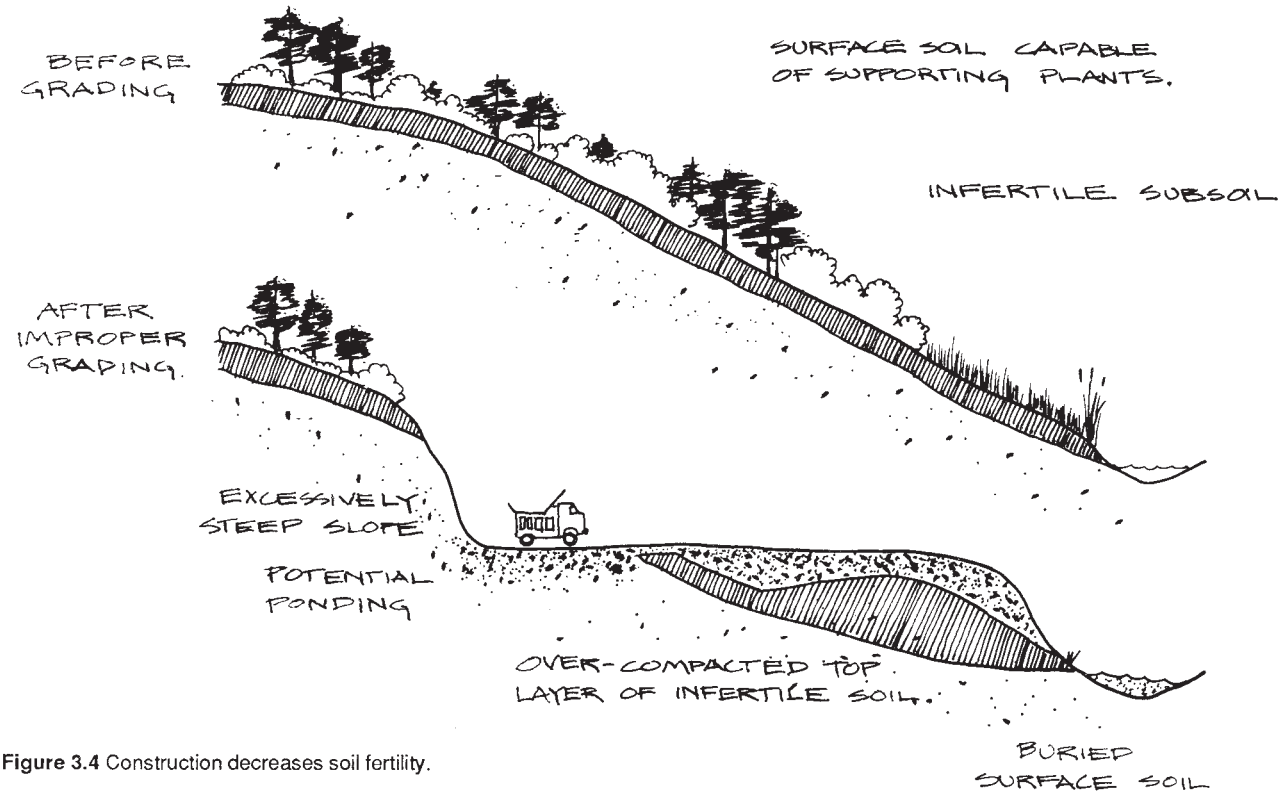

Figure 3.4 Construction decreases soil fertility.

according to the soil test ensures the most efficient expenditure of money for fertilizer and a minimum of excess fertilizer to pollute streams or groundwater. Soil sampling should begin well in advance of planting because 1 to 6 weeks are required to obtain soil test results.

Soil Limitations

Certain soil factors are difficult to modify and can impose severe limitations on plant growth. These include such things as depth, stoniness, texture, and properties related to texture such as water- and nutrient-holding capacity. Extremely coarse textures result in droughtiness and nutrient deficiencies. Fine textures, on the other hand, impede infiltration and decrease permeability, thereby increasing the volume of runoff. Toxic levels of elements such as aluminum, iron, and manganese are limiting to plant growth. However, these become less soluble as the pH is raised, so that toxicity problems can usually be eliminated by liming. Toxicities from industrial waste could also make the soil unsuitable for plant growth.

Portions of this manual refer to “poor” , “severe”, “droughty”, and “adverse” soils. These are subjective terms that require judgement based on experience in revegetating disturbed soils. They refer to soils that require special treatment beyond routine tillage and fertilization. *Appendix 8.01* provides guidance for identifying soils and predicting their characteristics.

SEASONAL CONSIDERATIONS

Newly constructed slopes and other unvegetated areas should be seeded and mulched, or sodded, as soon as possible after grading. Where feasible, grading operations should be planned around optimal seeding dates for the particular region. The most effective times for planting perennials generally extend from March through May and from August through October. Outside these dates the probability of failure is higher. If the time of year is not suitable for seeding permanent cover (perennial species), a temporary cover crop should be planted. Otherwise, the area must be stabilized with gravel or mulch. Temporary seeding of annual species (small grains, Sudangrass, or German millet) often succeeds at times of the year that are unsuitable for seeding permanent (perennial) species. Some annual species may be recommended for late winter through spring, summer, or late summer late fall. Planting dates differ with physiographic region.

Seasonality must be considered when selecting species. Grasses and legumes are usually classified as warm- or cool-season in reference to their season of growth. Cool-season plants produce most of their growth during the spring and fall and are relatively inactive or dormant during the hot summer months. Therefore fall is the most dependable time to plant them. Warm-season plants greenup late in the spring, grow most actively during the summer, and go dormant at the first frost in fall. Spring and early summer are preferred planting times for warm-season plants.

Variations in weather and local site conditions can modify the effects of regional climate. For this reason, mixtures including both cool- and warm-season species are preferred for low-maintenance cover, particularly in the Piedmont. Such mixtures promote cover adapted over a range of conditions. These mixtures are not desirable, however, for high-quality lawns, where variation in texture of the turf is inappropriate.

SELECTION OF VEGETATION

Species selection should be considered early in the process of preparing the erosion and sedimentation control plan. A diversity of vegetation can be grown in North Carolina, due to the variation in both soils and climate. However, for practical, economical stabilization and long-term protection of disturbed sites, species selection should be made with care. Many widely occurring plants are inappropriate for soil stabilization because they do not protect the soil effectively, or because they are not quickly and easily established. Plants that are preferred for some sites may be poor choices for others; a few can become troublesome pests.

Initial stabilization of most disturbed sites requires grasses and legumes that grow together without gaps. This is true even where part or all of the site is planted to trees or shrubs. In landscape plantings, disturbed soil between trees and shrubs must also be protected either by mulching or by permanent grass-

legume mixtures. Although mulching alone is an alternative, it requires continuing maintenance.

Mixture vs Single-Species Plantings

Single-species plantings are warranted in many cases, but they are more susceptible than mixtures to damage from disease, insects, and weather extremes. In addition, mixtures tend to provide protective cover more quickly. Consequently, the inclusion of more than one species should always be considered for soil stabilization and erosion control. Mixtures need not be elaborate. The addition of a quick-growing annual provides early protection and facilitates establishment of one or two perennials. More complex mixtures might include a quick-growing annual, one or two legumes, and one or two perennial grasses (*Practice Standards and Specifications: 6.11, Permanent Seeding*).

Companion or "Nurse" Crops

The addition of a "nurse" crop (quick-growing annuals added to permanent mixtures) is a sound practice for soil stabilization, particularly on difficult sites—those with steep slopes; poor, stony, erosive soils; late seedings, etc.—or in any situation where the development of permanent cover is likely to be slow. The nurse crop germinates and grows rapidly, holding the soil until the slower-growing perennial seedlings become established (Figure 3.5). Nurse crop recommendations are included in *Practice Standards and Specifications: 6.11, Permanent Seeding*.

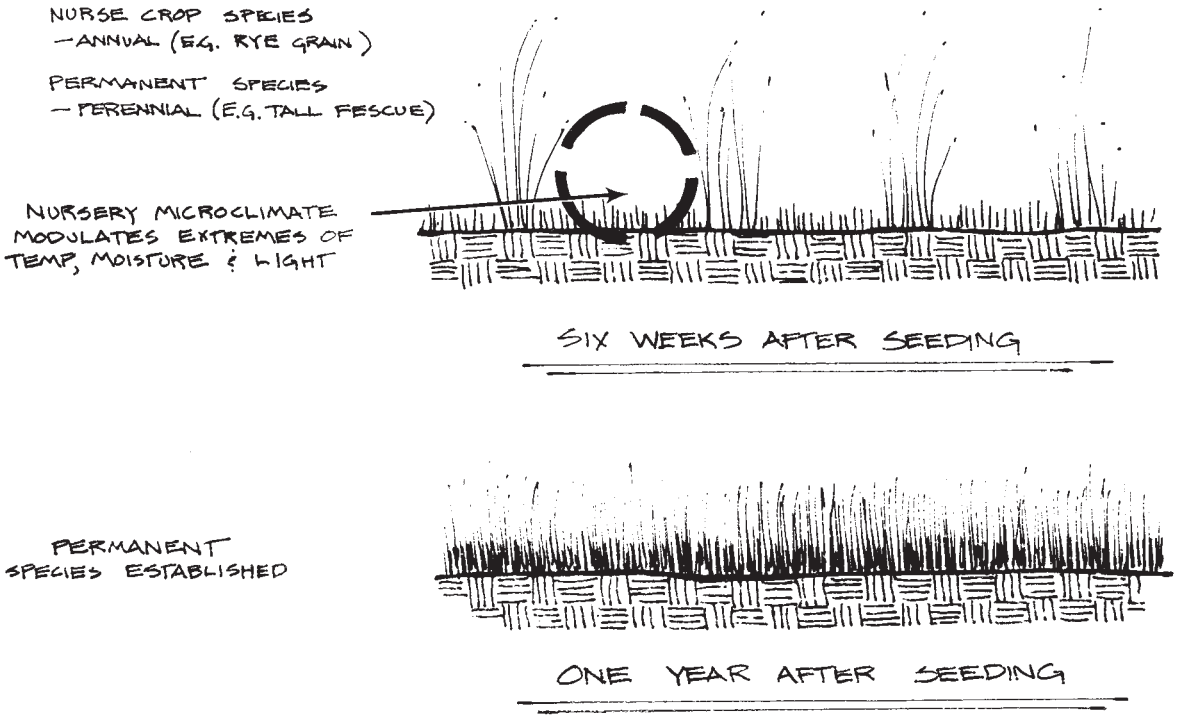

Figure 3.5 Nurse crops promote the establishment of permanent species.

Seeding rate of the nurse crop must be limited to avoid crowding, especially under optimum growing conditions. Seeding rates recommended in this manual are designed to avoid overcrowding. **Do not exceed the recommended rate.**

Plants Species Selection

Table 3.1 is a summary of the major plant species available for stabilization use in North Carolina. This summary is based on research and many years of field experience. Using this information makes plant selection straightforward for most situations. Recommended plants and some of more limited application are listed in Table 8.02a, *Appendix 8.02*, along with their botanical names. Specific seeding rates are given in *Practice Standards and Specifications: 6.10, Temporary Seeding*, and *6.11, Permanent Seeding*.

Annuals

Annual plants grow rapidly and then die in one growing season. The are useful for quick, temporary cover or as nurse crops for slower-growing perennials.

Winter rye (grain) is usually superior to other winter annuals (wheat, oats, crimson clover, etc.) both for temporary seeding and as a nurse crop in permanent mixtures. It has more cold-hardiness than other annuals and will germinate and grow at lower temperatures. By maturing early, it offers less competition during the late spring period. a critical time in the establishment of perennial species. Rye grain germinates quickly and is tolerant of poor soils. Including rye grain in fall-seeded mixtures is almost always advantageous. but it is particularly helpful on difficult soils and erodible slopes or when seeding is late. Overly thick stands of rye grain will suppress the growth of perennial seedlings. **Limit seeding rates to the suggested level.** About 50 lb/acre is the maximum for this purpose, and where lush growth is expected, that rate should either be cut in half, or rye grain should be eliminated from the mixture.

Table 3.1 Plants Recommended for Revegetating Disturbed Soils in North Carolina

	Annuals	Perennials
Cool-season grasses	Winter rye (grain)	Tall fescue Kentucky bluegrass Creeping Bentgrass Deertongue Indian Grass Indian Seaoats Viginia Wild Rye
Warm-season grasses	German millet Sudangrass	Bermudagrass Bahiagrass Big Bluestem Centipedegrass Little Bluestem Switchgrass
Legumes	Annual lespedeza Partridge Pea	Crownvetch Sericea lespedeza Roundhead lespedeza
Marsh plants		Smooth cordgrass Saltmeadow cordgrass Giant cordgrass
Dune plants		American beachgrass Sea oats Bitter panicum Saltmeadow cordgrass

Annual ryegrass is **not recommended** for use in North Carolina (Figure 3.6). It provides dense cover rapidly, but may be more harmful than beneficial in areas that are to be permanently stabilized. Annual ryegrass is highly competitive, and if included in mixtures, it crowds out most other species before it matures in late spring or early summer, leaving little or no lasting cover. It can be effective as a temporary seeding, but if allowed to mature the seed volunteers and seriously interferes with subsequent efforts to establish permanent cover. Winter rye (grain) is preferable in most applications.

German millet is a fine-stemmed summer annual, useful for temporary seeding, as a nurse crop, and for tacking mulch. It is better adapted to sandy soils than are the Sudangrasses. Normal seeding dates are between the last frost in spring and the middle of August.

Sudangrass—Only the small-stemmed varieties of Sudangrass should be used. Like German millet, Sudangrass is useful for temporary seeding and as a nurse crop, but it is adapted to soils higher in clay content. Seed for common Sudangrass is not always available, but other small-stemmed types may be used, such as the hybrid Trudan. **The coarse-stemmed sorghum-Sudangrass hybrids are not satisfactory as nurse plants and are not appropriate for erosion control**. Seeding dates are similar to those for German millet.

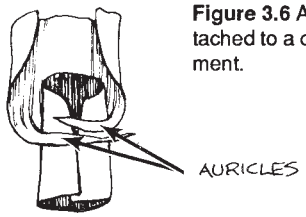

Figure 3.6 Annual ryegrass is recognized by flowers directly attached to a central stem and claw-like auricles at the leaf attachment.

Annual lespedeza is a warm-season, self-reseeding annual legume that is tolerant of low fertility and is adapted to climate and most soils throughout the state. It is an excellent nurse crop in the spring, filling in weak or spotty stands the first season without suppressing the perennial seedlings. It is often seeded with sericea lespedeza. Annual lespedeza can heal damaged areas in the perennial cover for several years after initial establishment. Two varieties of annual lespedeza are generally available: Kobe and Korean. Kobe is superior on sandy soils and generally preferable in the Coastal Plain. Both Kobe and Korean are satisfactory in the Piedmont. Korean is better in the mountains as the seeds mature earlier.

The preferred seeding dates for annual lespedeza are in late winter to early spring. It can be mixed with fall seedings. In which case some seeds remain dormant over the winter and germinate the following spring. However, it is more effective to overseed with lespedeza in February or March.

Partridge pea, *Chamaecrista fasciculate,* is an annual erect legume plant that reaches a height of 1 to 3 feet. The plant can be used along road banks and stream banks to control erosion. Partridge pea most commonly occurs as a pioneer or colonizer of disturbed areas. **Although partridge pea foliage is nutritious, it can be poisonous and should be considered potentially dangerous to cattle**. Drill seeds at 1/4 to 3/4 inch deep at a rate of 10 lbs/ac pure live seed.

If the seed is broadcast, increase seeding rate and cover seed by lightly disking or by cultipacking. Planting should be conducted late winter (March) to late spring (May) while soil moisture is still high. Germination is improved by scarification of the seed prior to planting. Seed should also be inoculated with the correct species of *Rhizobium* before planting. Fertilizer should be applied at the recommended rate, based on soil samples, at time of planting.

Cool-Season Perennials

Perennial plants remain viable over winter and initiate new growth each year. Stands of perennials persist indefinitely under proper management and environmental conditions. They are the principal components of permanent vegetative cover.

Cool-season perennials produce most of their growth during the spring and fall and are more cold-hardy than most warm-season species. Descriptions of the species recommended for vegetating disturbed soils follow.

Creeping Bentgrass is a tough, cool-season perennial grass tolerant of infertile, droughty, somewhat acid soils. It can be a useful component of mixtures on dry, stony slopes in the western half of the state, particularly in the Mountain region.

Deertongue, *Dichanthelium clandestinum,* is a native perennial, warm season grass that reaches a height of one to three feet. It grows well on non-cultivated soil. Because of its tolerance to low pH, high concentrations of aluminum, and droughty infertile conditions, it is commonly found to volunteer on such sites. Deertongue should be seeded as early as possible in the spring. Seed dormancy is easily overcome when deertongue is planted during cool weather, so that natural stratification in the soil will occur. If the site conditions restrict early spring planting, it is advisable to sow seed in the late fall or early winter, while dormant. On sites where conventional farm equipment can operate, prepare seedbed as normal for a pasture planting. Use a grain or grass drill; do not place seed deeper than one inch. In sand and gravel pits, the method of choice is to broadcast, then 'track' the seed with lime and fertilizer in with a bulldozer. Hydroseed steep or rough areas, but expect this method to result in less success than those outlined above. Expect slow establishment of seedings. Deertongue is most often planted in mixtures with other warm season grasses such as switchgrass with the total rate of 12-15 pounds per acre. Typically, deertongue does not exceed 3 pounds of the per-acre mix.

Eastern Bottlebrush Grass, *Elymus hystrix,* is a perennial bunch grass that grows 2 to 5 feet tall. It is useful for riparian plantings, preferring shade and moist soils. It is closely related to Virginia Wildrye, which is described below.

Kentucky bluegrass is the dominant lawn grass in the Mountains and Upper Piedmont. It has higher lime and fertility requirements than the other perennial grasses used in these regions. Bluegrass spreads by strong rhizomes and, where adapted, is an excellent soil stabilizer, readily filling in damaged spots. As with tall fescue, it has been the subject of intensive breeding activity in recent years, resulting in varieties with more heat tolerance and resistance to hot-weather diseases. Mixtures of these new varieties with improved types of tall fescue are becoming popular, particularly for Piedmont lawns, where they can be used in both sun and partial shade.

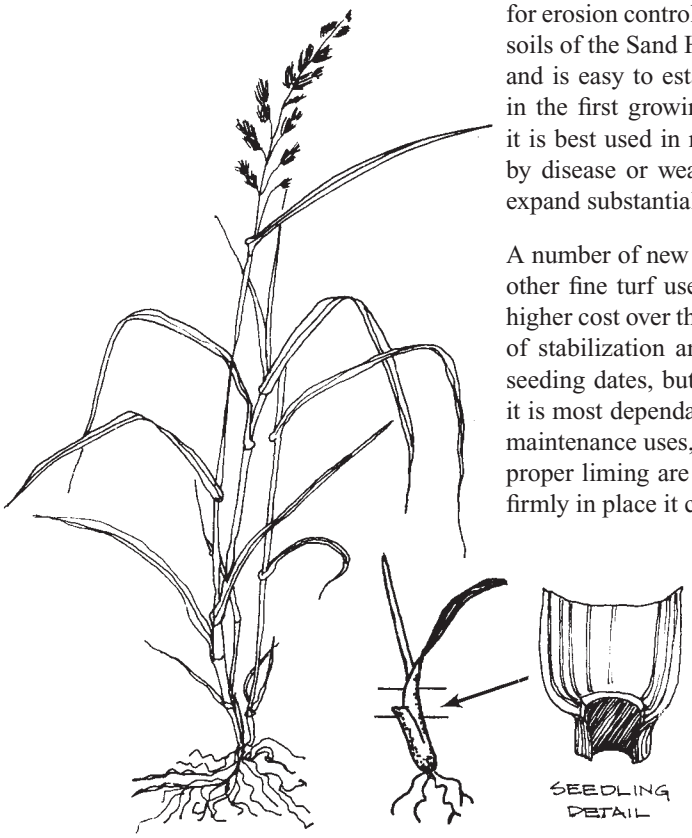

Figure 3.7 Tall fescue is a common perennial easily confused with ryegrass. Seedhead is branched, loose and open. Auricles are absent in young plants (compare with Figure 3.6).

Tall fescue, a cool-season grass, is the most widely used species in the state for erosion control (Figure 3.7). It is well-adapted to all but the most droughty soils of the Sand Hills and Coastal Plain. It thrives in full sun to partial shade and is easy to establish. If seeded in the fall, it provides stabilization early in the first growing season. Because of tall fescue's bunchy growth habit, it is best used in mixtures. It does not fill in well where areas are damaged by disease or weather; however, short rhizomes enable individual plants to expand substantially in thin stands.

A number of new varieties of tall fescue are becoming available for lawn and other fine turf use and several offer definite improvements. However, their higher cost over the old standby, KY31, is seldom justified solely for purposes of stabilization and erosion control. Tall fescue tolerates a wide range of seeding dates, but, with the possible exception of high mountain elevations, it is most dependable when fall-planted. It is adapted to both high- and low-maintenance uses, tolerating frequent or no mowing. Liberal fertilization and proper liming are essential for prompt establishment of tall fescue, but once firmly in place it can tolerate minimal maintenance almost indefinitely.

Fox Sedge *Carex vulpinoidea,* is a perennial, clump-forming grass that grows to be 12 to 40 inches tall and spreads up to 24 inches wide. It is a pioneer species that colonizes wet open sites soon after disturbance. It grows in full sun to part shade and likes normal to wet soils. It is most abundant in clayey soils, but also does well in sand and loam. It is planted in locations that remain moist, near streams, springs, ponds, and moist woods. It is an excellent colonizer of wetland mitigation sites. Fox sedge seedlings should be spaced 1 to 2 feet apart. This converts to approximately 1000 roots per acre.

Indiangrass, *Sorghastrum nutans,* is a native, perennial, warm-season grass, and a major component of the tall grass vegetation which once dominated the prairies of the central and eastern United States. Indiangrass grows 3 to 5 feet tall. Indiangrass can be used on critical-area seeding, for roadside cover, and on areas subject to wind erosion. It grows best in deep, well-drained floodplain soils. However, it is highly tolerant of poorly to excessively well-drained soils, acid to alkaline conditions, and textures ranging from sand to clay. The optimum time to plant is from early May to late June. If seed is drilled for solid stands, use 6 to 8 pounds per acre rate PLS (pure live seed). For broadcast seedings, the rate should be between 12 and 15 pounds per acre. Seeding depth is ¼ inch. If seed is broadcast or hydroseeded, it is important to "incorporate" the seed by tracking with a heavy machine to improve the seed to soil contact.

Indian Seaoats, (Indian Woodoats) *Chasmanthium latifolium,* is a native, rhizomatous perennial often found in small colonies. The leaf shape and size are similar to many of the larger species of panic (*Panicum* species) grasses. The height of this grass and the inflorescence (seed cluster) somewhat resemble domestic oats; thus, the common name "wood, creek, or sea oats." It inhabits areas along streams and water banks, shaded slopes and bottomland hardwoods. It is never found on droughty sites.

Rice Cutgrass, *Leersia oryzoide,* is a native cool season grass that grows and flowers comparatively late in summer. Rice cutgrass is valuable for wildlife habitat improvement, wetland restoration, and erosion control in ditches and other watercourses. This plant's creeping rhizomes and spreading habit are good for sediment stabilization along the immediate shorelines of streams and lakes. Tolerant of highly acidic conditions (pH=3), the species is being studied for use in constructed wetlands and the treatment of acid mine drainage. Rice cutgrass can be found in a variety of wet, sunny, and partially shaded sites. Late summer or early fall seeding is recommended. Seeds will germinate the following spring. A seeding rate of 1 lb/acre of pure live seeds will result in 8 live seeds per square foot. Rarely sown alone due to cost, it typically comprises 1 to 20% of a seed mix.

Shallow Sedge, *Carex lurida,* is found in wet meadows, marshes, seeps, shores of ponds, lakes, and streams, open swamp forests, ditches, mostly in acidic, often sandy soils. Its grass-like leaves grow up to 3' tall from short stout rhizomes. The seedheads resemble small sweetgum balls but do not grow above the foliage. This sedge is less prone to summer dieback and remains attractive during warm weather. The sedge grows best in wet to moist soil in full sun to partial shade. It is used in water gardens and establishing native plants in wet meadows, swampy areas, or around bodies of water.

Soft Rush, (Common Rush) *Juncus effusus* is a slow spreading, clump forming, grass-like perennial which emerges from a stout branching rootstock. New shoots emerge and develop in late summer, reaching up to 4 feet tall at maturity the following spring. The dense stands that soft rush form have deep fibrous root systems, which provide very good shoreline protection, filtration, and nutrient up-take. It inhabits fresh to brackish marshes, swamps, ditches, and moist seasonal wetlands and meadows. Soft rush is tolerant of diverse site conditions, but thrives in direct sun, finely textured soils, pH from 4.0 to 6.0, and shallow water (less than 6 inches).

Sweet Woodreed, *Cinna arundinacea,* is a perennial bunch grass that grows to almost 5 feet in height. It is most common in moist woodlands and swamps, depressions, along streams, and in floodplain and upland woods, and is less frequent in wet meadows, marshes, and disturbed sites. It flowers in late summer to fall. It is shade tolerant and prefers moist soils.

Virginia wildrye, *Elymus virginicus,* is a native, cool season, perennial bunchgrass that grows two to three feet in height. Virginia wildrye prefers moist soils, high soil fertility, heavier soil textures, and it is shade tolerant. It can be found scattered on shaded banks, along fencerows and in open woodlands. Virignia wildrye can be drilled at a minimum of 10 pounds of pure live seed per acre, or broadcast at 20 pounds of pure live seed per acre. If it is a critical area planting or if dense coverage is desired, double the seeding rate. When including Virginia wildrye in a seed mixture, reduce the seeding rate accordingly.

Warm-Season Perennials

Warm-season perennials initiate growth later in the spring than cool-season species and experience their greatest growth during the hot summer months. Warm-season species are not generally used in the Mountains; most species thrive only in areas on the Coastal Plain. The following grasses have proven the most useful for soil stabilization.

Bermudagrass is an aggressive, sod-forming warm-season perennial adapted to a wide range of well-drained to excessively drained soils throughout the Piedmont and Coastal Plain. It is very drought-resistant, has considerable salt-tolerance, and can be very useful for erosion control, particularly on deep sands in the Sand Hills and near the coast. Bermudagrass is not at all shade tolerant.

Figure 3.8 Common Bermudagrass.

Common Bermudagrass (Figure 3.8) should be used with **extreme care** as it quickly becomes a pest in croplands, gardens, and landscape plantings, spreading rapidly both vegetatively and by seed. It is difficult to control and almost impossible to eradicate.

The turf- and hay-type hybrids do not produce viable seed and less aggressive. Therefore, they are much easier to control and are less likely to become pests. However, hybrid Bermudas are more costly to establish because they must be planted from sprigs or plugs. In fact, the cost involved in establishing turf-type hybrids makes them generally practical only for fine turf use.

Common Bermudagrass is normally seeded in late spring using "hulled" seed (seed from which the outer covering or bracts have been removed). Unhulled seed may be used in fall-seeded mixtures because it lies dormant over winter and germinates in the spring. Hybrid varieties are planted in early spring, while soil moisture is still adequate. They may be planted later if water is available for irrigation.

Bahiagrass is a warm-season perennial grass adapted to the lower Piedmont and Coastal Plain. It tolerates dry, acid, low-fertility soils. Bahiagrass produces a fairly dense sod suitable for low-maintenance lawns, were it not for the production of unsightly seedheads (1-2 ft high) throughout the growing season.

Unfortunately, the strain of Bahiagrass generally available, Pensacola, is occasionally subject to winter-kill at this latitude. Consequently, it should not be relied upon in pure stands. The Wilmington strain is more cold-tolerant, but seed is not generally available.

Big Bluestem, *Andropogon gerardii,* is a native, perennial, warm season grass that occurs from the short grass prairie region to the Atlantic Ocean. It is tufted, forms sod, and has short, scaly rhizomes. Big bluestem is tall, reaching a height of 6 to 8 feet on most sites where it is protected from grazing. Big bluestem is a top choice for erosion control plantings on sites with moderately well drained to excessively well-drained soils. Generally, it is planted in combination with other warm season grasses on these sites. Big bluestem should be seeded as early in the spring as possible. Conventional tillage should be used where practical. The seeding rate for broadcast or no-till methods should be 7 to 12 pounds PLS per acre.

Centipedegrass is adapted to well-drained, medium- to coarse-textured soils in the eastern Piedmont and Coastal Plain. Generally used as a low- to moderate-maintenance turf, it is tolerant of infertile, low pH soils, heat, drought, and cold.

A serious problem with centipedegrass is its slow growth rate. Also, when grown on dry sands, irrigation is required to avoid severe pest injury (pearl bug). It is not tolerant to traffic or compaction.

Centipedegrass can be established from seeds or sprigs, but a nurse crop must be used to provide initial erosion control. The best planting months are March through July.

Little Bluestem, *Schizachyrium scoparium,* is a medium height grass with coarse stems and basal leaves. As a warm season grass it begins growth in late spring and continues through the hot summer period until the first killing frost. It is easily mistaken for common broomsedge. Because of its growth habit and adaptability to a wide range of soil conditions, little bluestem is useful as a component of revegetation mixes. Little bluestem is one of the most widely distributed native grasses in North America. It will grow on a wide variety of soils but is very well adapted to well-drained, medium to dry, infertile soils. The plant has excellent drought and fair shade tolerance, and fair to poor flood tolerance. The seeding rate for establishing a pure stand with broadcast or no-till methods should be 7 to 12 pounds PLS per acre.

Switchgrass, *Panicum virgatum,* is a perennial sod-forming grass that grows 3 to 5 feet tall. It is a valuable soil stabilization plant on strip-mine spoils, sand dunes, dikes, and other critical areas. It performs well on shallow and droughty soil. Its slick, free-flowing seed can be planted with most seed drills or with a broadcast spreader. A planting rate of approximately 10 pounds PLS per acre is recommended. Seedbeds should be firmed with a roller prior to the drilling or broadcasting of seed. If seeds are planted using the broadcast method, the area should be rolled afterward to help cover the seed.

Weeping lovegrass seeds often germinate and become established under drier conditions than most other cultivated grasses, and it is quite drought-resistant.

It is a bunch grass, forming distinct clumps that spread very little. This makes perfect stands essential, otherwise erosion between clumps may become serious. Further, this species is usually rather short-lived in North Carolina. Lovegrass is sometimes mixed with sericea lespedeza, which fills in between the clumps and persists after the weeping lovegrass declines. However it can be too competitive as a nurse crop. Where permanent cover is desired, it is usually best to start with species that provide more complete cover of a more permanent nature.

Weeping lovegrass is not recommended because its clumping growth habit and lack of persistence reduce its value for erosion control under North Carolina conditions.

Perennial Legumes

Crownvetch is a deep-rooted, perennial legume with spreading rootstocks, adapted to the Mountain region and to the cool slopes (north and east exposures) in the Piedmont. It is useful on steep slopes and rocky areas that are likely to be left unmowed. Crownvetch requires a specific *Rhizobium* inoculant, which may have to be obtained by special order. It can be seeded in the spring or fall. Crownvetch does not respond well to mowing.

Roundhead lespedeza *Lespedeza capitata* is a palatable and nutritious native legume that is a desirable component in warm season grass mixtures, providing nitrogen fixation. It is drought tolerant and grows in full sun. This herbaceous, native, perennial plant has stiff, erect stems that are 2-5 feet tall. The flowers are crowded in conspicuous green ball like clusters that are grouped together at the tips of the stems. The pea-like flowers are easy to over look unless the plant is examined closely. Roundhead lespedeza can be easily established by using a native grass drill with a legume seed box attachment. For a solid stand seeding, plant in late fall or early spring into a firm seedbed at a rate of 4 pounds PLS (pure live seed) per acre. Seed should be planted at a depth of ¼ to ½ inch. Use scarified inoculated seed when seeding in the spring, and unscarified inoculated seed when making a fall dormant planting.

Sericea lespedeza is a deep-rooted, drought-resistant perennial legume, adapted to all but the poorly drained soils of the state. It is long-lived, tolerant of low-fertility soils, and pest free, and it fixes nitrogen. It can be a valuable component in most low-maintenance mixtures. Sericea is a slow starter and should not be expected to contribute much to prevention of soil erosion the first year; however, it strengthens rapidly and persists indefinitely on suitable sites. Seedings that include sericea require mulch and should include nurse plants such as German millet, Sudangrass, or annual lespedeza. "Scarified," or roughened, seed should be used for spring seeding of sericea because it germinates more readily. Un-scarified seed is recommended for fall-seed mixtures because many of the seeds will lie dormant over winter and germinate early the next spring.

Sericea does not tolerate frequent mowing and may be considered unsightly because the old top growth breaks down slowly.

Coastal Dune Vegetation

Revegetation of construction sites on the barrier islands of North Carolina requires special attention to selection of plant species. In the foredune area there are only a few plants that tolerate the stresses of the beach environment. They must be able to survive salt spray, sand blasting, burial by sand, saltwater flooding, drought, heat, and low nutrient supply. The species commonly planted in this environment is American beachgrass. Other well-suited plants are sea oats, bitter panicum, and coastal panicgrass. In areas behind the foredune, coastal Bermudagrass has been used effectively for stabilization. In low, moist areas saltmeadow cordgrass may be transplanted.

American beachgrass is a cool-season perennial dune grass. It is the principal species presently planted in North Carolina for dune building and as a stabilizer in the foredune zone. Easy to propagate, it establishes and grows rapidly, and is readily available from commercial nurseries. It is an excellent sand trapper capable of growing upward with 4 ft of accumulating sand in one season. New plantings are usually effective at trapping wind-blown sand by the middle of the first growing season.

While extremely valuable for initial stabilization and dune building in disturbed areas, this grass has several serious problems under North Carolina conditions. It is a northern species, probably occurring naturally only as far south as Currituck Banks. It is severely affected by heat and drought and tends to deteriorate and die behind frontal dunes as the sand supply declines. Also, it is susceptible to a fungal disease (Marasmius blight) and a soft scale insect (*Eriococcus carolinae*). Consequently, beachgrass plantings should be reinforced by the inclusion of sea oats and bitter panicum. Dead patches should be replanted to sea oats, bitter panicum, of seashore elder. Sea oats and bitter panicum may be planted without beachgrass, but these plants are more expensive.

The selection of adapted strains is important, as the southern limit of adaptation for this species is approached along the North Carolina coast. Hatteras, a North Carolina selection, has been used effectively for many years. Cape is a northern strain that looks good at first but does not persist well here. Bogue is a more recent selection, better than Cape but not as thoroughly tested as Hatteras.

Figure 3.9 Sea oats.

Sea oats (Figure 3.9) is the primary native dune builder from Currituck Banks southward to Mexico. It is a warm-season grass, vigorous, drought- and heat-tolerant, and an excellent sand trapper once fully established. The seed heads, borne on 3 to 4 ft stalks, are quite decorative, This plant is much more tolerant of reduced sand and nutrient supply than American beachgrass and may persist in backdune areas indefinitely.

Sea oats is limited in commercial availability. Pot-grown seedlings may be transplanted to the dunes when 12 to 16 inches in height.

Early growth in the dunes is generally slower than American beachgrass, and transplants are not effective in trapping sand the first season. This, and the scarcity of commercial supplies, make planting in pure stands generally impractical. However, on the North Carolina coast enough sea oat plants should be included in American beachgrass plantings to assure a future seed supply if there is not already one nearby. This will provide for gradual replacement as the beachgrass stand weakens.

Bitter panicum is a warm-season, perennial grass occurring on and near sand dunes from New England southward to Mexico. It rarely, if ever, produces viable seed and must be propagated vegetatively. It is also highly palatable to grazing animals. These characteristics probably account for its scarcity on many beaches.

Bitter panicum is most useful for inclusion in American beachgrass plantings to encourage long-term stability. It is relatively pest-free, both under nursery conditions and on the dunes. Commercial supplies are limited, but could be readily expanded to meet demand.

When buried, this grass will root at most nodes. Place runners in trenches, leaving several inches of the tip exposed, or set small plants, as with American beachgrass. Stands respond vigorously to nitrogen fertilization.

Saltmeadow cordgrass is a warm-season perennial useful for transplanting on low areas subject to saltwater flooding. It is a heavy seed producer and is often the first plant on moist sand flats. It collects and accumulates blowing sand, creating an environment suitable for dune plants.

Saltmeadow cordgrass is easy to transplant on moist sites but does not survive on dry dunes. Plants should be dug from young, open stands. Survival of transplants from older, thick stands is poor. Nursery production from seed is relatively easy, and the pot-grown seedlings transplant well. Propagation by seed is possible, but the percentage of viable seed varies.

Intertidal Vegetation

There is often a need to transplant vegetation in the intertidal zone of estuaries to reduce shoreline erosion, to stabilize dredged material, or for mitigation. The concept of mitigation—permitting disturbance of natural marshes in return for establishing new marshes—is receiving attention and has been tested in North Carolina. Such a trade-off may be justified if a small inclusion of marsh in a construction site is a problem. Decisions on permits are made on an individual basis by personnel of the appropriate State and Federal regulatory agencies.

In saltwater areas, smooth cordgrass is transplanted in the intertidal zone from mean sea level to mean high water, and saltmeadow cordgrass from mean high water to the storm tide level. In brackish water areas (10 parts per thousand or less of soluble salts), giant cordgrass may be used in the intertidal zone. Greenhouse-grown seedlings of these plants can be obtained from commercial sources, but usually only on special order. Transplants may also be dug from young, open natural stands in the case of smooth and saltmeadow cordgrass.

Smooth cordgrass is the dominant plant in the regularly flooded intertidal zone of saltwater estuaries along the Atlantic and Gulf Coast of North America. The plant is adapted to anaerobic, saline soils that may be clayey, sandy, or organic. It will tolerate salinities of 35 parts per thousand (ppt) but grows best from 10 to 20 ppt. Plant height varies from 1 to 7 ft depending on environmental conditions and nutrient supply. It produces a dense root and rhizome mat that helps prevent soil movement. Transplants can be obtained by digging from new, open stands of the grass or may be grown from seed in pots. Seed are collected in September and stored, covered with seawater, and refrigerated. The plants and seedlings grow rapidly when transplanted on favorable sites.

Saltmeadow cordgrass is a fine-leaved grass, 1 to 3 ft in height, that grows just above the mean high tide line in regularly flooded marshes, and throughout irregularly flooded marshes. It can be propagated in the same way as smooth cordgrass except that seed may be stored dry under refrigeration. A stand of saltmeadow cordgrass provides good protection from storm wave erosion.

Giant cordgrass grows in brackish, irregularly-flooded areas. Stems are thicker and taller than in the other cordgrasses, growing to a height of 9 to 10 ft. Seedlings are easy to produce in pots and these can be successfully transplanted, but survival of plants dug from existing stands is poor.

ESTABLISHING VEGETATION

Topsoiling

The surface layer of an undisturbed soil is often enriched in organic matter and has physical, chemical, and biological properties that make it a desirable planting and growth medium Those qualities are particularly beneficial to seedling establishment. Consequently, **where practical, topsoil should be stripped off prior to construction and stockpiled for use in final revegetation of the site**. Planning such stabilization measures from the beginning of the project may eliminate costly amendments and repair measures later. Topsoiling may not be required for the establishment of less demanding, lower maintenance plants, but it is essential on sites having critically shallow soils or soils with other severe limitations. It is essential for establishing fine turf and ornamentals.

The need for topsoiling should be evaluated, taking into account the amount and quantity of available topsoil and weighing this against the difficulty of preparing a good seedbed on the existing subsoil. Where a limited amount of topsoil is available, it should be reserved for use on the most critical areas. In many cases topsoil has already been eroded away or, as in wooded sites, it may be too trashy.

Site Preparation

The soil on a disturbed site must be modified to provide an optimum environment for germination and growth. Addition of topsoil, soil amendments, and tillage are used to prepare a good seedbed. At planting the soil must be loose enough for water infiltration and root penetration, but firm enough to retain moisture for seedling growth. Tillage generally involves disking, harrowing, raking, or similar method. Lime and fertilizer should be incorporated during tillage.

Soil Amendments

Liming is almost always required on disturbed sites to decrease the acidity (raise pH), reduce exchangeable aluminum, and supply calcium and magnesium. Even on the best soils, some fertilizer is required. Suitable rates and types of soil amendments should be determined through soil tests. Limestone and fertilizer should be applied uniformly during seedbed preparation and mixed will with the top 4 to 6 inches of soil.

Organic amendments, in addition to lime and fertilizer, may improve soil tilth, structure, and water-holding capacity—all of which are highly beneficial to seedlings establishment and growth. Some amendments also provide nutrients. Examples of useful organic amendments include well-rotted sawdust, well-rotted animal manure and bedding, crop residue, peat, and sludge from municipal sewage or industrial waste.

Organic amendments are particularly useful where topsoil is absent, where soils are excessively drained, and where soils are high in clay. The application of several inches of topsoil usually eliminates the need for organic amendments.

Sludge is an inexpensive amendment that can be very beneficial to plant growth, but proper planning and careful management are essential to its use. Sludge adds nutrients, primarily nitrogen and phosphorus, improves soil structure, and increases organic matter. Types of sludge available include municipal sewage, and waste from textile, wood processing, and fermentation industries. Nutrient content of the sludge depends on the source, but is much lower than that of commercial fertilizers. Sewage sludge may be used in reclamation of disturbed sites, **but always check local or State regulations before attempting to use sewage sludge**.

Sludges may sometimes be high in heavy metals such as nickel and cadmium. North Carolina has published guidelines for the use of sludges which must be followed to maximize effectiveness and avoid pollution of streams. Runoff and erosion control are essential where sludge has been applied. Near residential areas odors can also be a problem. Sludge is available in either solid or liquid forms. Solid or semi-solid forms are broadcast on sod or soil and may or may not be incorporated. Liquid sludge is irrigated, broadcast, broadcast and incorporated, or injected directly beneath the surface.

Surface Roughening

A rough surface is especially important to seeding sloped areas. Contour depressions and loose surface soil help retain lime, fertilizer, and seed. A rough surface also reduces runoff velocity and increases infiltration.

Because slopes steeper than 3:1 are not usually mowed, they can be left quite rough by grooving, furrowing, tracking, or stairstep grading (*Practice Standards and Specifications: 6.03, Surface Roughening*). Stairstep grading is particularly helpful where there are large amounts of soft rock, because each step catches material in which vegetation can become established.

Slopes flatter than 3:1, which may be mowed, should be grooved by disking, harrowing, raking, or operating planting equipment on the contour. On gentle slopes with sufficient mulch, this is sufficient to retain seed and soil amendments and promote infiltration. Seed should be broadcast soon after surface roughening, before the surface is sealed by rainfall.

Planting Methods

Seeding is by far the fastest and most economical method that can be used with most species. However, some grasses do not produce seed and must be planted vegetatively. Seedbed preparation, liming, and fertilization are essentially the same regardless of the method chosen.

Seeding

Uniform seed distribution is essential. This is best obtained using a cyclone seeder (hand-held), drop spreader, conventional grain drill, cultipacker seeder, or hydraulic seeder. The grain drill and cultipacker seeders (also called grass seeder packer or Brillion drill) are pulled by a tractor and require a clean, even seedbed.

On steep slopes hydroseeding may be the only effective seeding method. Surface roughening is particularly important when preparing slopes for hydroseeding. In contrast to other seeding methods, a rugged and even trashy seedbed gives the best result.

The "insurance" effect of extra seed has been taken into account in arriving at the rates recommended in this manual. **Rates exceeding those given are not recommended because over-dense stands are more subject to drought and competitive interference**.

Because uniform distribution is difficult to achieve with hand-broadcasting, it should be considered only as a last resort. When hand-broadcasting of seed is necessary, uneven distribution may be minimized by applying half the seed in one direction and the other half at right angles to the first. Small seed should be mixed with sand for better distribution.

A "sod seeder" (no-till planter) is used to restore or repair weak cover. It can be used on moderately stony soils and uneven surfaces. It is designed to penetrate the sod, open narrow slits, and deposit seed with a minimum of surface disturbance. Fertilizer is applied in the same operation.

Inoculation of legumes—Legumes have bacteria, rhizobia, which invade the root hairs and form gall-like "nodules." The host plant supplies carbohydrates to the bacteria, which supply the plant with nitrogen compounds fixed from the atmosphere. A healthy stand of legumes, therefore, does not require nitrogen fertilizer. *Rhizobium* species are host specific—a given species will inoculate some legumes but not others. Successful establishment of legumes, therefore, requires the presence of specific strains of nodule-forming, nitrogen-fixing bacteria on their roots. In areas where a legume has been growing, sufficient bacteria may be present in the soil to inoculate seeded plants, but in other areas the natural *Rhizobium* population may be too low.

In acid subsoil material, if the specific *Rhizobium* is not already present, it must be supplied by mixing it with the seed at planting. Cultures for this purpose are available through seed dealers.

Sprigging and Plugging

Sprigging refers to planting stem fragments consisting of runners (stolons) or lateral, below-ground stems (rhizomes), which are sold by the bushel. This method can be used with most warm-season grasses and with some ground covers, such as periwinkle. Certain dune and marsh grasses are transplanted using vertical shoots with attached roots or rhizomes. Sprigs can be broadcast or planted in furrows using a tobacco transplanter. Under favorable conditions, the hay-type, hybrid Bermudagrasses will cover-over in one growing season from sprigs spaced on 6-ft centers. Lawn-type plants are usually sprigged much more thickly.

Broadcasting is easier but requires more planting material—3 to 10 bu/1,000ft^2 for Bermudagrass. Broadcast sprigs must be pressed into the top 1/2 to 1 inch of soil by hand or with a smooth disk set straight, special planter, cultipacker, or roller.

Plugging differs from sprigging only in the use of plugs cut from established sod, in place of sprigs. It is usually used to introduce a superior grass into an old lawn. It requires more planting stock, but usually produces a complete cover more quickly than sprigging.

Sodding

In sodding, the soil surface is completely covered by laying cut section of turf. It is practiced in this region with turf-type Bermudas, Kentucky bluegrass, tall fescue, and blugrass-tall fescue mixtures, and is limited primarily to lawns, steep slopes, and sod waterways. A commercial source of high-quality turf is required and water must be available. Plantings must be wet down immediately after planting, and kept well watered for a week or two thereafter.

Sodding, though quite expensive, is warranted where immediate establishment is required, as in stabilizing drainage ways and steep slopes, or in the establishment of high-quality turf. If properly done, it is the most dependable method and the most flexible in seasonal requirements. Sodding is feasible almost any time the soil is not frozen.

Irrigation

Irrigation, though not generally required, can extend seeding dates into the summer and insure seedling establishment. Damage can be caused by both under- and over-irrigating. If the amount of water applied penetrates only the first few inches of soil, plants may develop shallow root systems that are prone to desiccation. **If supplementary water is used to get seedlings up, it must be continued until plants become firmly established**.

Irrigation requirements depend upon current weather conditions—rainfall, temperature, humidity, etc. A statewide weather forecast including information on planting and growing conditions is available through the North Carolina Agricultural Extension Service by calling “Teletip” (1-800-662-7301). This can be used to determine day-to-day watering needs.

Mulching

Mulch is essential to the revegetation of most disturbed sites, especially on difficult sites such as southern exposures, channels, and excessively dry soils. The steeper the slope and the poorer the soil, the more valuable it becomes. In addition, mulch fosters seed germination and seedling growth by reducing evaporation, preventing soil crusting, and insulating the soil against rapid temperature changes.

Mulch may also protect surfaces that cannot be seeded. Mulch prevents erosion in the same manner as vegetation, by protecting the surface from raindrop impact and by reducing the velocity of overland flow. There are a number of organic and a few chemical mulches that may be useful, as well as nets and tacking materials (*Practice Standards and Specifications: 6.14, Mulching*).

Grain straw (wheat, oats, barley, rye) is the most widely used and one of the best mulches. However, there are other materials that work well but may be only locally available. Mulching materials covered in this manual have their respective advantages and appropriate applications, and a material should not be selected on the basis of cost alone.

MAINTENANCE

Satisfactory stabilization and erosion control requires a complete vegetative cover. Even small breaches in vegetative cover can expand rapidly and, if left unattended, can allow serious soil loss from an otherwise stable surface. A single heavy rain is often sufficient to greatly enlarge bare spots, and the longer repairs are delayed, the more costly they become. Prompt action will keep sediment loss and repair cost down. New seedlings should be inspected frequently and maintenance performed as needed. If rills and gullies develop, they must be filled in, re-seeded, and mulched as soon as possible. Diversions may be needed until new plants take hold (Figure 3.10).

Maintenance requirements extend beyond the seeding phase. Damage to vegetation from disease, insects, traffic, etc., can occur at any time. Herbicides and regular mowing may be needed to control weeds—dusts and sprays may be needed to control insects. Herbicides should be used with care where desirable plants may be killed. **Weak or damaged spots must be relimed, fertilized, mulched, and reseeded as promptly as possible**. Refertilization may be needed to maintain productive stands.

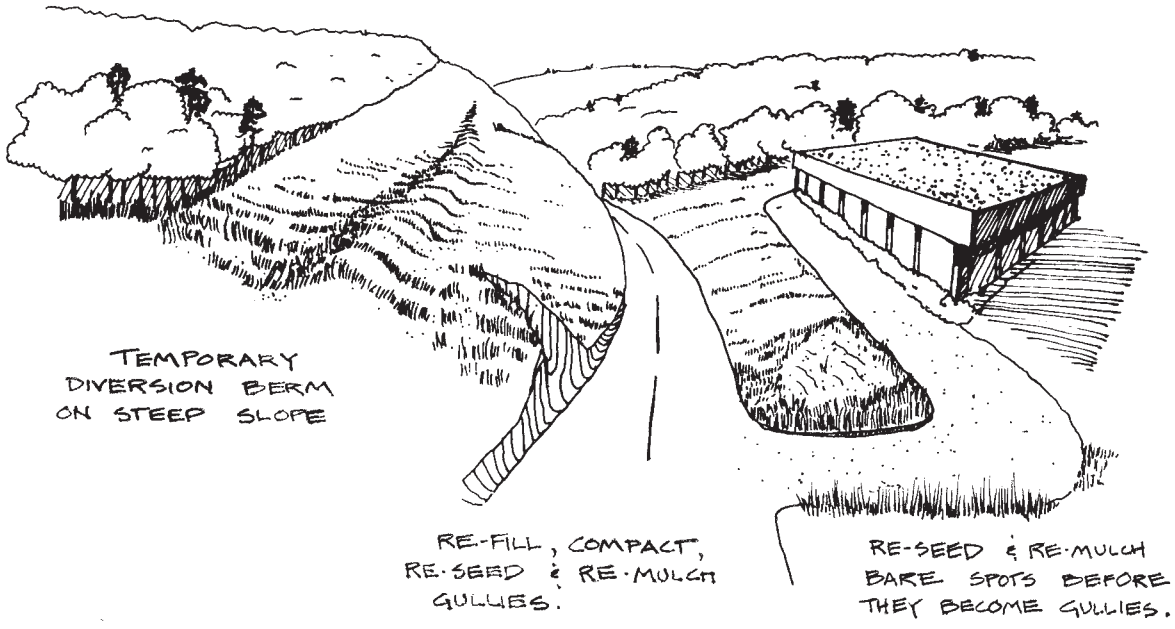

Figure 3.10 Maintenance of vegetative cover.

Vegetation established on disturbed soils often requires additional fertilization. Frequency and amount of fertilization can best be determined through periodic soil testing. A fertilization program is required for the maintenance of fine turf and sod that is mowed frequently. Maintenance requirements should always be considered when selecting plant species for revegetation.