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AIR FORCE AFM 126-8

LANDSCAPE DESIGN AND PLANTING

DEPARTMENTS OF THE ARMY, AND THE AIR FORCE
AUGUST 1988

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*__This manual supersedes TM 5-830-2/AFM 88-17, Chap 2 dated September 1983, and TM 5-830-4/AFM 18-17, Chap 4 dated June 1976.__

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CHAPTER 1
INTRODUCTION

1-1. Purpose. This manual provides planting design guidelines for preserving. and improving the quality of the visual environment on military installations; prescribes standard practices and techniques for planting and initial care of plant materials; and includes guidance for the selection and establishment of turf.

1-2. Scope. The criteria and guidelines contained in this manual apply to Army and Air Force installations in the continental United States. Planting design guidance in this manual is generally applicable for all installations. However, each installation should develop planting plans tailored to the specific landscape project. In addition to general design guidance, this manual describes planting techniques and methods for the successful establishment of plants. Factors which are critical in the selection of turfgrass are discussed; these include site evaluation, proposed use of the site and required maintenance.

1-3. References. Appendix A contains a list of references used in this document. In addition to the references, recommendations on the selection, establishment, and maintenance of plants tolerant to specific site conditions can be obtained from the local Agricultural Extension Service, the local Soil Conservation Service and from state and local park, forest, and wildlife agencies.

CHAPTER 2
LANDSCAPE DESIGN GUIDELINES

Section I. Principles of Landscape Design

2-1. Unity. Unity is the most important principle of good planting design.

a. One means of introducing unity into a planting design is to enclose open spaces or frame vistas. Large open spaces may be visually unified into attractive areas for a variety of uses such as athletic fields and parade grounds. Where a view beyond the open area reveals objectionable features in the winter, a screen composed primarily of evergreen plants should be used. Where the view beyond is pleasant, deciduous trees and shrubs may be used in the screen.

b. A plant or plant mass can be either a focal object that provides visual delight or a support element that helps to reinforce or frame a focal element such as a view, a piece of sculpture or a building (fig 2-1).

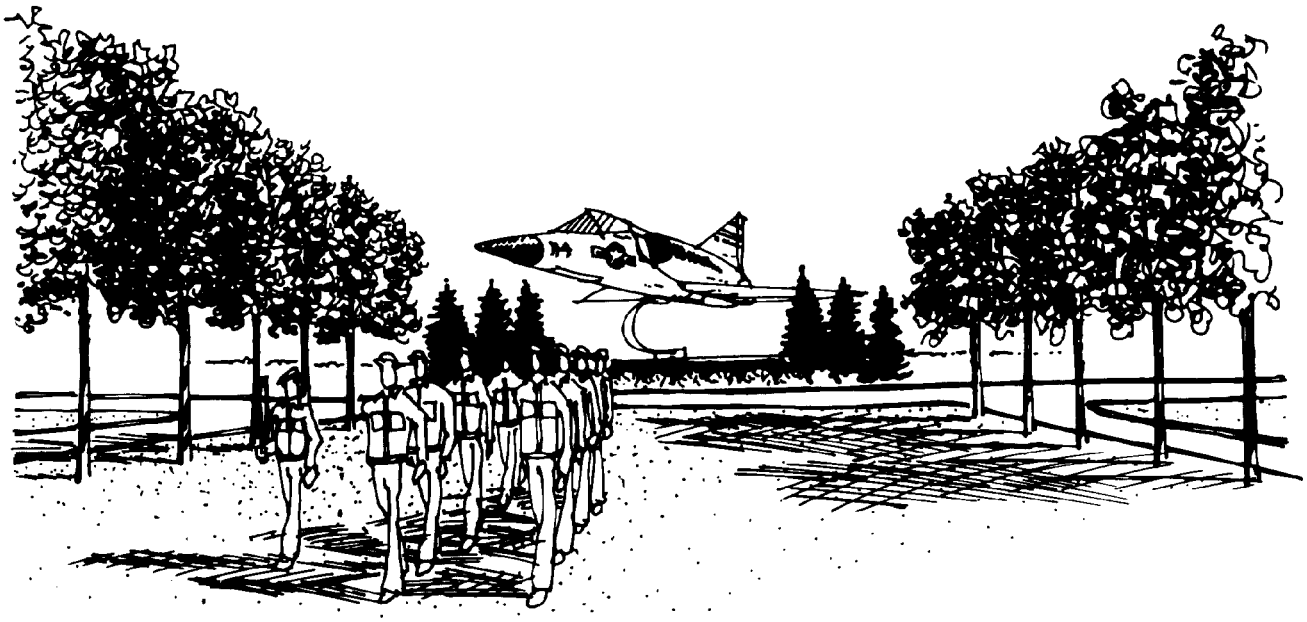


Figure 2-1. Creating a focal point.

c. In an area of buildings otherwise characterized by mundane or incompatible architecture, the colors and textures of mature trees and shrubs tend to lessen the contrast between buildings and visually unify the total composition of the area (fig 2-2).

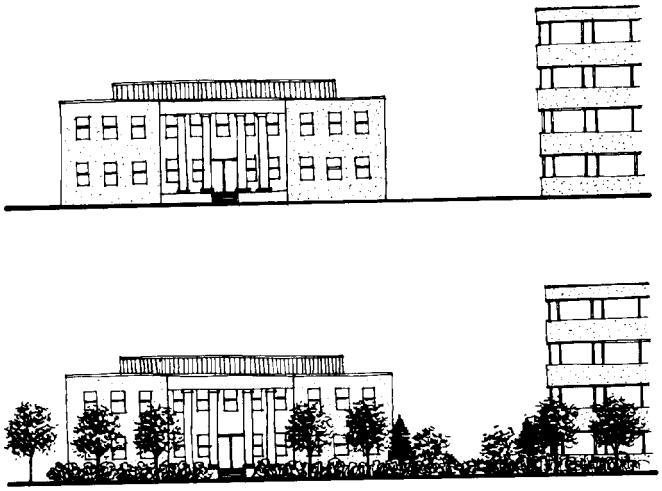


Figure 2-2. Mediating element.

d. Plants can play two roles in unifying a building with its setting. At a detail level, plants can visually integrate a building with its site where the outdoor ground plane meets the building mass (fig 2-3). On a larger scale, plants can blend a building into its overall setting.

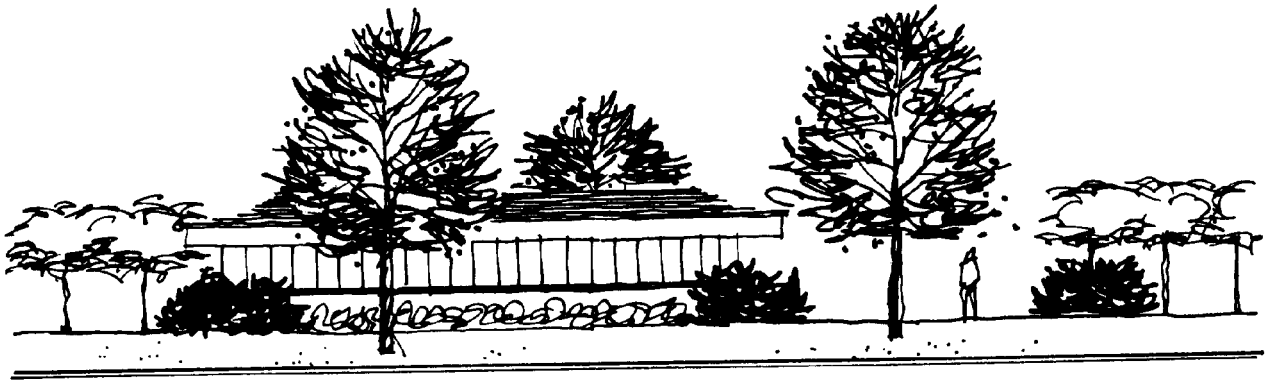


Figure 2-3. Transition/blending elements.

2-2. Balance. Balance is the arrangement of plants or groups of plants to achieve visual equilibrium by employing either a symmetrical or asymmetrical arrangement.

a. Symmetrical or formal balance exists where the same number, size and type of plants are placed on each side of a visual dividing line such as a walkway (fig 2-4). The important of certain areas or selected buildings and the approaches to them can be emphasized by formal planting. However, formal plantings require high maintenance to retain a consistently satisfactory appearance. Plant losses are conspicuous and replacement may be difficult and costly. To minimize labor and expense, planting should be predominantly informal with only occasional use of symmetry to accent a particular architectural or site feature.

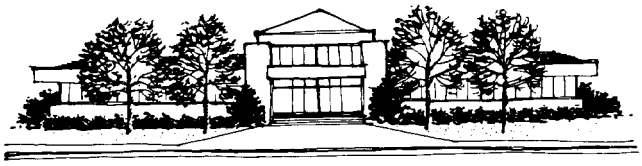


Figure 2-4. Symmetrical plantings.

b. Asymmetrical balance can be achieved by using different types of plants in a mass or group which appear to balance. For example, a large shade tree may have a balancing effect when used with a group of smaller ornamental trees or shrubs (fig 2-5). Asymmetrical balance is difficult to achieve because seasonal changes and growth alter the appearance of plants. However, if plants are carefully selected, a balanced appearance is possible throughout the year. Some deciduous plants, for example, have branching patterns which balance with other plants in the composition even during the winter when foliage color has changed or disappeared.



Figure 2-5. Assymetrical plantings.

2-3. Contrast. Contrast is achieved by the arrangement of plants in relation to each other in such a way that differences in size, shape, texture or color are emphasized. Plants can be selected and arranged to focus attention on other plants, as in the case of an evergreen hedge used as a background for flowering shrubs. A mass of low plants provides a contrasting base for an entrance sign and in this way focuses attention on the sign. Similarly, large trees may be used to emphasize a building entrance or other important site feature, such as a gateway. In these cases, the contrast between trees and architectural features draws attention when seen either from a distance or nearby (fig 2-6).

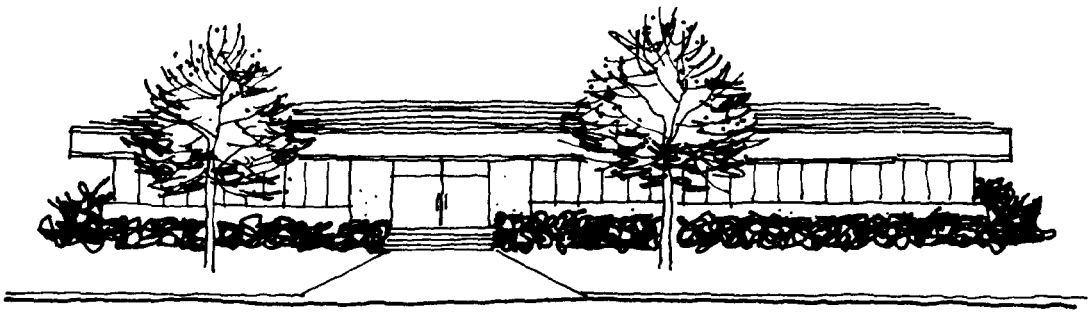


Figure 2-6. Emphasis.

2-4. Rhythm. Rhythm is achieved by a regular spacing of single plants or plant masses, such as a row of trees or shrubs, or the repetition of similar plant groupings. Rhythmic plantings produce emphasis and unity in the landscaping. Rhythmically spaced street trees create a strong visual pattern which is effective in drawing attention to main traffic circulation routes on the installation (fig 2-7). Rhythm may also be created by regular placement of landscape elements according to color, shape or size.



Figure 2-7. Directional element.

2-5. Color and texture. The color and texture of plants can improve the appearance of an area. Because light, shade and the location of the observer affect the perception of both color and texture, the amount of sunlight falling on plants should be considered in their placement. The appearance of plants with distinctive texture or color will change depending on whether they are seen with hack or front lighting, from a distance, or close-up. Plant surfaces may range from glossy to dull; this affects their ability to reflect light and alters their appearance.

a. Colors are classified in two basic categories: warm colors (red, orange, yellow), which are stimulating, and cool colors (violet, blue, green), which are calming. Color can provide contrast or emphasis in a planting design. Masses of foliage or blossoms of a single color generally have greater visual impact than a mixture of several colors. "One of each kind" is a design style to avoid. Care should be exercised to pick colors which are harmonious when seen together. Many deciduous plants provide a source of color in the fall with brightly colored foliage. The brightly colored berries of some evergreens, such as holly, provide fall and winter color.

b. Texture of plant materials can range from coarse to fine (fig 2-8). The texture of a particular plant may appear to change depending on the distance from which it is viewed and its relationship to surrounding materials. A planting screen which is intended to serve as a security aid can be very effective if it is composed of rough, thorny plants.

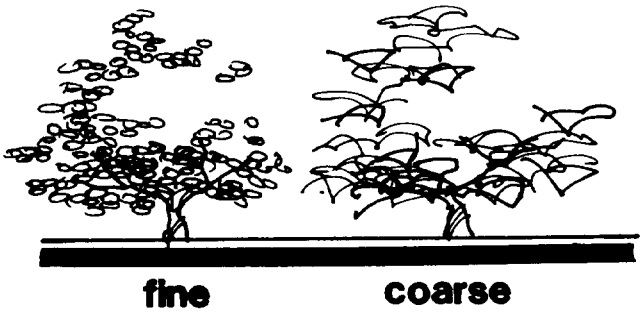


Figure 2-8. Texture.

2-6. Simplicity. Landscapes should be simple in design so that excessive maintenance is not required. The shapes of shrub beds should be uncomplicated where they border mowed turf. Large power mowing equipment cannot operate efficiently in areas cluttered with isolated plantings. Hand trimming or the use of small mowers is labor intensive and therefore costly. Lawn areas are simpler to mow if trees are confined to shrub beds or ground cover areas. Ground covers or shrubs should be considered for use in areas that are small or difficult to mow.

2-7. Ultimate effect. Planting should be as permanent as possible. The ultimate effect must be kept constantly in mind when selecting and arranging plants. The final landscape plan should indicate the plants at approximately two-thirds of their ultimate size to assist in correct spacing. Short-lived plants which grow quickly should be used only where an immediate effect is essential or where, in the course of time, they may be removed as the space they occupy is filled by growth of more permanent plants. Tall plants should usually not be planted under windows. For example, evergreen trees cut off light, air and views from windows unless they are pruned at frequent intervals. Plantings in the vicinity of traffic intersections should be low-growing or high-branching so that they do not block the vision of passing motorists. When limited budgets preclude the purchase of large plants, it is usually better to plant the desired trees and shrubs in smaller sizes and wait for the desired effect than to compromise by substituting inappropriate species. The use of even a few large trees can create an early effect of permanence.

2-8. Spatial articulation. Plants can be used to enclose spaces and to separate spaces from one another

(fig 2-9). Plantings can also be used to direct people through outdoor spaces by visually defining and rein forcing patterns of movement (fig 2-10). The degree of enclosure, separation, or movement depends to a large extent on the density and type of plantings. The effectiveness of deciduous plantings varies with the season, whereas evergreens are consistent year-round.

a. Planting screens. Plants with dense, abundant foliage may be used as screens to conceal objects or views. Plantings require more space and maintenance than fences or walls used for screening purposes. Where limited area prohibits use of plant screens, a fence or wall softened in appearance with vines or a few shrubs may be an effective and economical solution.

b. Buffer plantings. Plantings used as buffers may be composed of lawn areas; shade trees planted in groups; or combinations of lawn, shade trees, flowering trees and evergreen shrubs (fig 2-11).

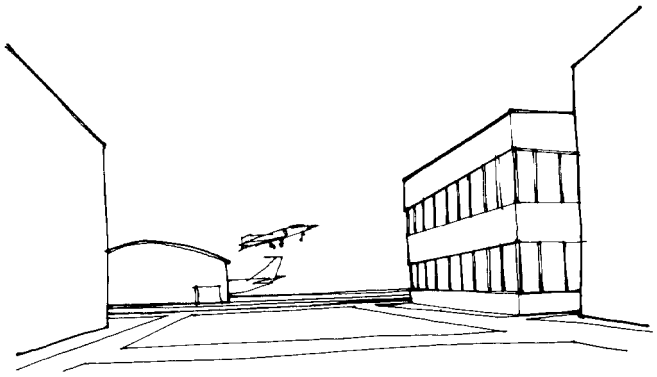




Figure 2-9. Spatial articulation.

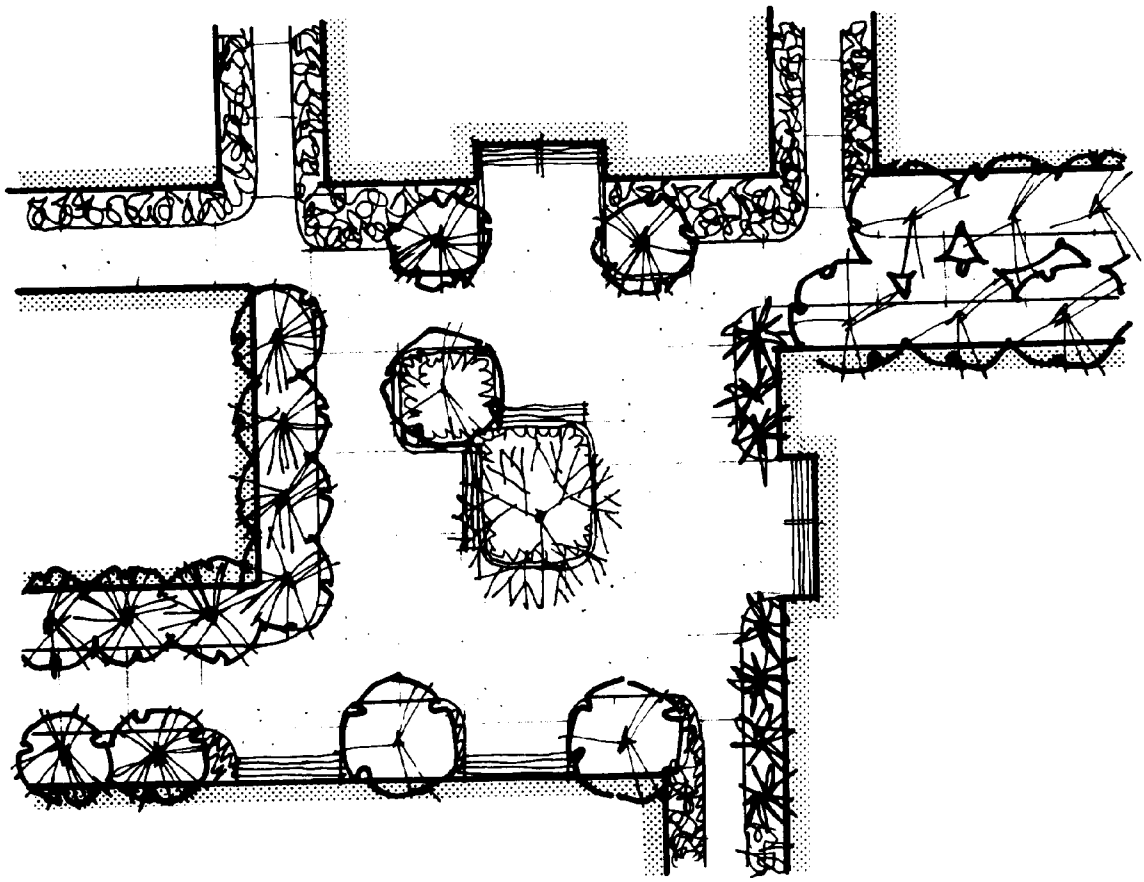


Figure 2-10. Movement sequence.

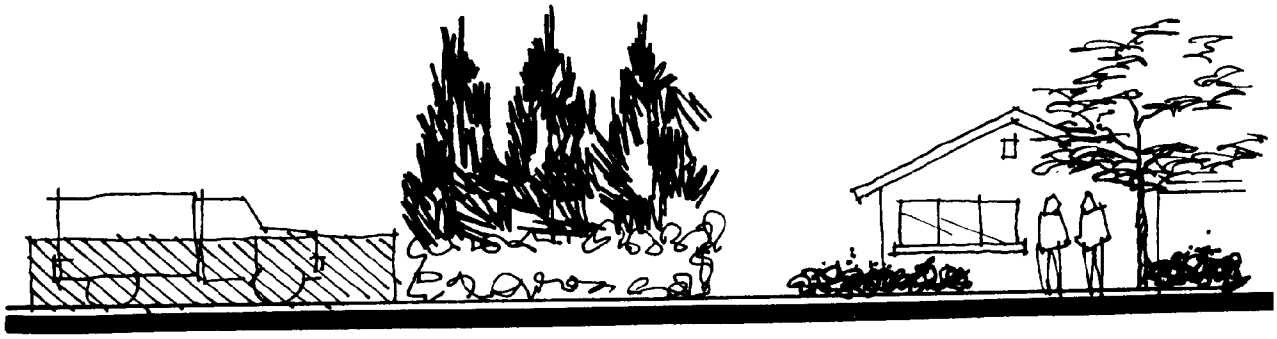


Figure 2-11. Buffering element.

Section II. Attributes of Planting

2-9. Aesthetic value. Plantings made for utilitarian purposes, such as screening service areas or shading hot pavements, will simultaneously improve the appearance and enhance the livability of an area. The use of plantings can introduce visual variety, create vistas, and relieve bareness. One desirable effect of planting is a reduction in the monumental scale of structures; this relieves the visual oppressiveness created by large buildings and adds to the psychological comfort of the viewer. Plantings can separate groups of buildings into several pleasantly framed units and enhance individual buildings within each group. Shrubs and small trees arranged in strategic groups around a building often improve overall appearance by softening structural lines. This technique integrates the building and its site and diverts attention from unattractive structural features. Vines on large, blank masonry walls can be attractive but should not be used where injury to the structure may result.

2-10. Wildlife conservation. Plant materials support wildlife and can be used to increase or decrease the number and variety of animal species. Landscaping so as to attract animal species such as songbirds and small game can add to the richness of residential and administrative areas. Plants used for this purpose usually have the added advantage of being native and requiring low maintenance. Care must also be taken so that wildlife habitats that are nuisances, such as black-bird roosts, do not contribute to bird aircraft strike hazard (BASH) problems.

2-11. Environmental Controls.

a. Energy conservation. Skillful utilization of plants significantly increase the energy efficiency of buildings. Air-conditioning requirements for most buildings result from solar energy absorbed by building surfaces. By shading those portions of the building receiving the most sun, cooling requirements can be significantly reduced (fig 2-12). During summer months, deciduous trees provide shade, while during winter months, their bare branches allow sunlight to reach exterior building surfaces and reduce heating requirements.

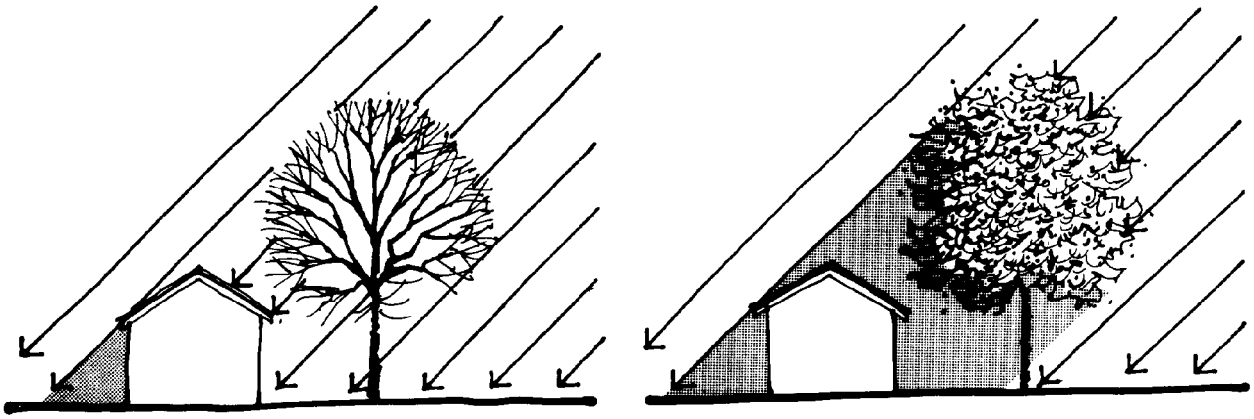


Figure 2-12. Solar radiation control.

b. Reduction of noise. Dense foliage is of some use in absorbing and deadening noise (fig 2-13). In locations such as family housing areas located near main traffic arteries, deep belts of planting may prove beneficial in reducing traffic noise. Sounds caused by breezes rustling through leaves and branches can mask undesirable noise.

c. Wind control. Wind is a climatic factor that can be either pleasant or unpleasant depending on air temperatures, relative humidity and air velocities. Plants can be used to break, guide, deflect or filter the wind and thereby alter its effects (fig 2-14). To properly design for wind control using plant materials, a basic knowledge of air dynamics is necessary. Information about the directions of prevailing winds and their average speeds for different seasons of the year is also necessary.

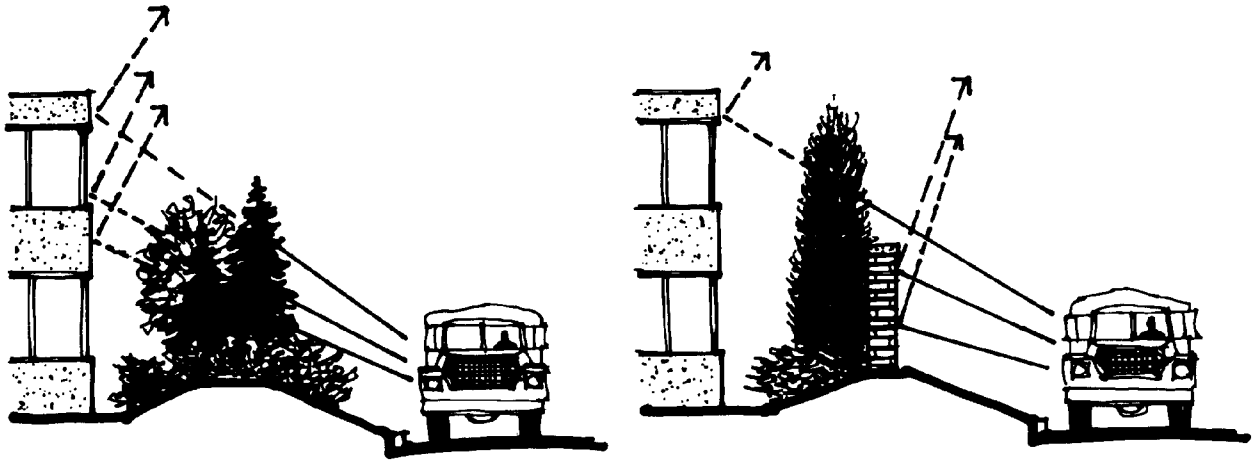


Figure 2-13. Traffic noise control.

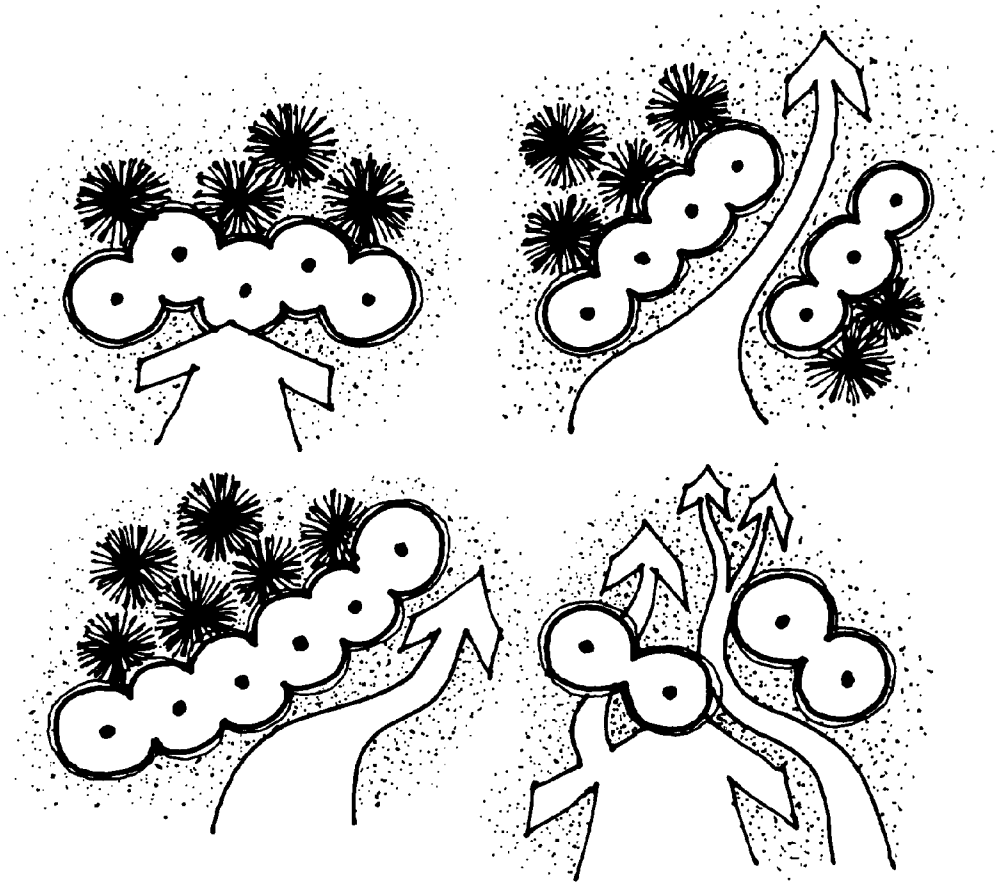


Figure 2-14. Wind control—directional.

(1) When plants are used as a wind barrier, wind can generally be affected for a lateral distance of 2 to 5 times the height of the barrier on the windward side and a lateral distance of 10 to 15 times the height of the barrier on the leeward side (fig 2-15).

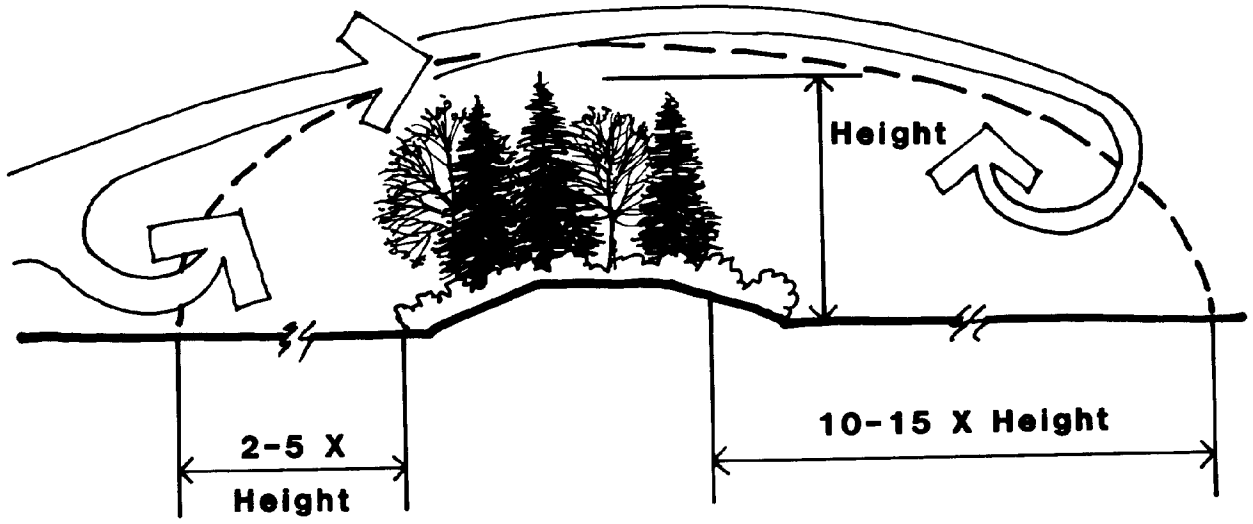


Figure 2-15. Wind barrier.

(2) Plants tend to be better windbreaks than fences or walls because they permit some degree of wind penetration. The effective distance of wind control on the leeward side is increased by use of penetrable screens because less turbulence is created. A planting density of about 60 percent offers maximum effectiveness (fig 2-16).

(3) The depth of a shelter belt, or wind screen, has no real effect on the amount of wind protection provided; the primary factors influencing effectiveness are the height and density of planting (fig 2-17).

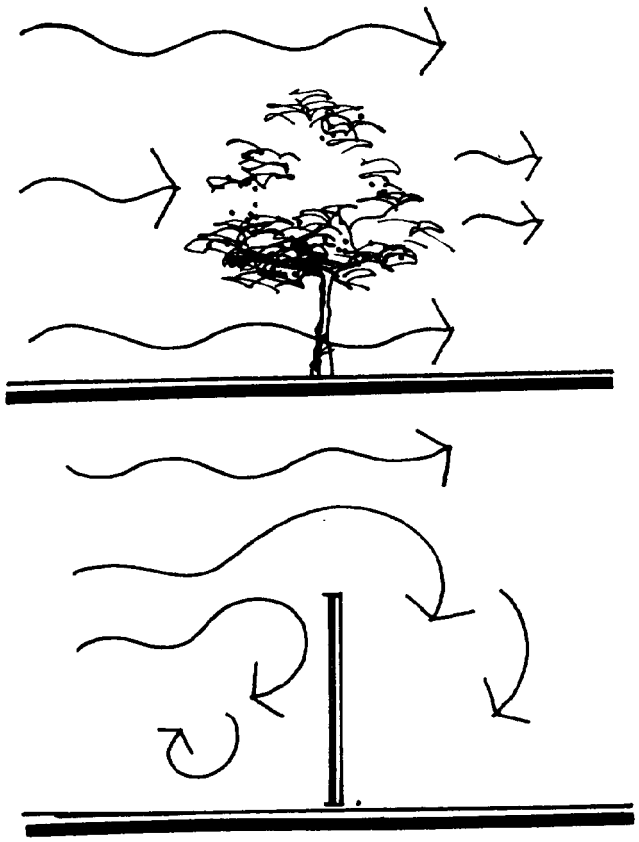


Figure 2-16. Wind turbulence.

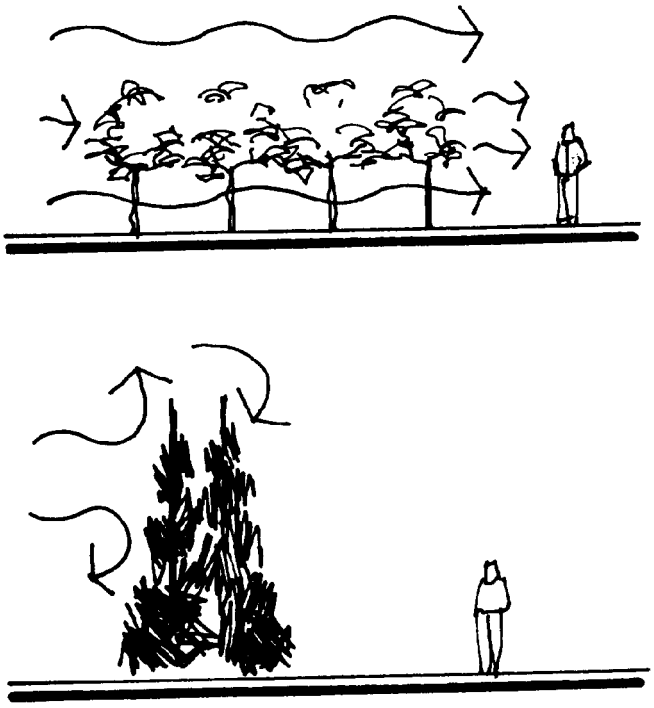


Figure 2-17. Increasing wind protection.

(4) Irregular forms and spacing tend to provide a more effective windbreak than evenly spaced, uniform plants. A variety of plant types and sizes should be included to improve the efficiency of a windbreak (fig 2-18).

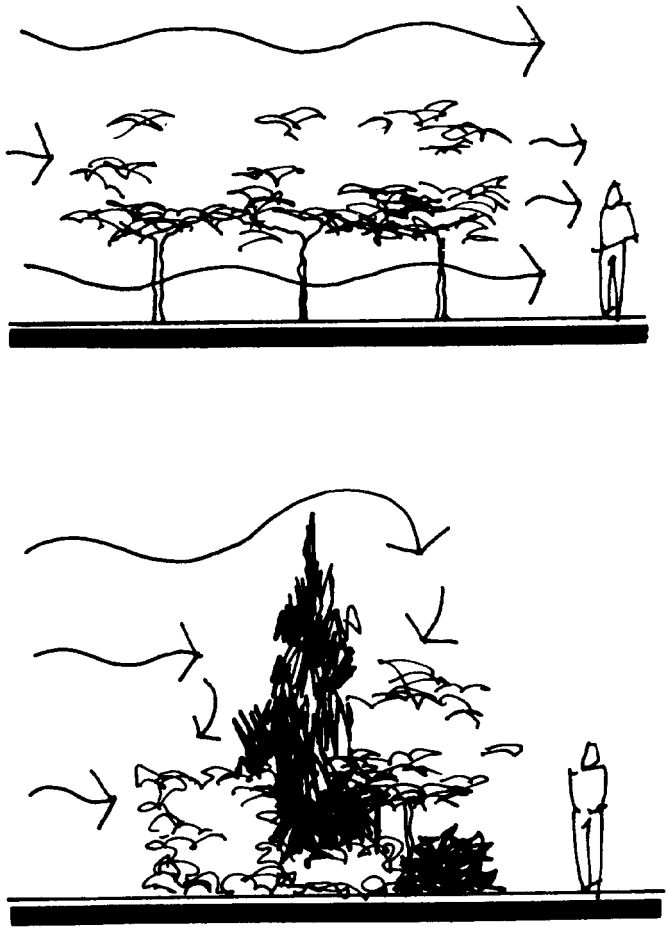


Figure 2-18. Use of irregular forms.

(5) Evergreen plants that branch to the ground are the most effective year-round windbreaks. Deciduous trees and shrubs are effective only in the summer.

(6) Wind velocities will be increased if wind is permitted to penetrate under a high-canopied tree. A gap in a windbreak tends to create stronger winds by funneling the air (fig 2-19).

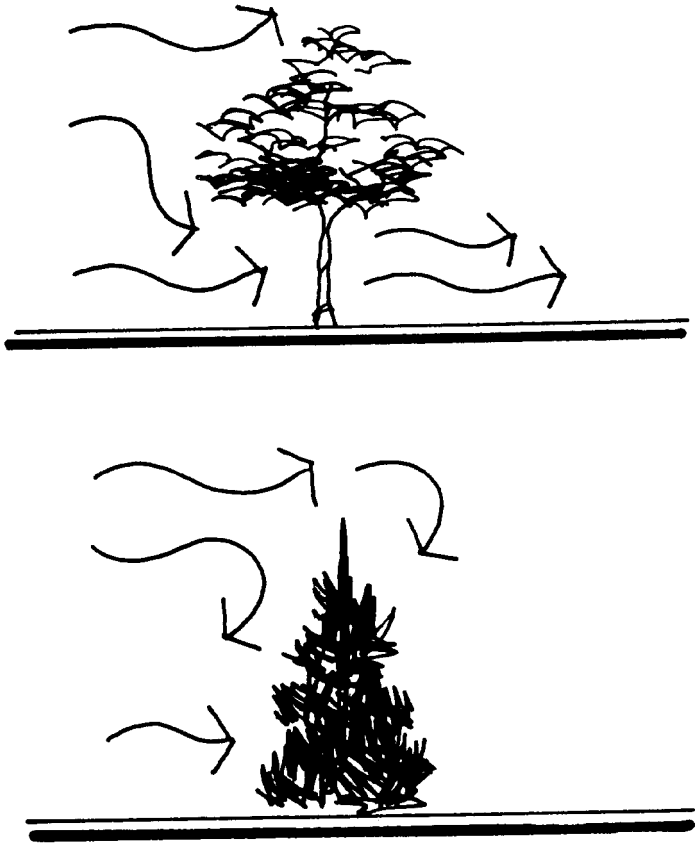


Figure 2-19. Wind velocities.

(7) Drifting snow may be controlled by a series of plant barriers which alternately increase and decrease wind velocities. This can be accomplished by sweeping an area of snow with strong winds and depositing the snow where wind velocity decreases (fig 2-20).

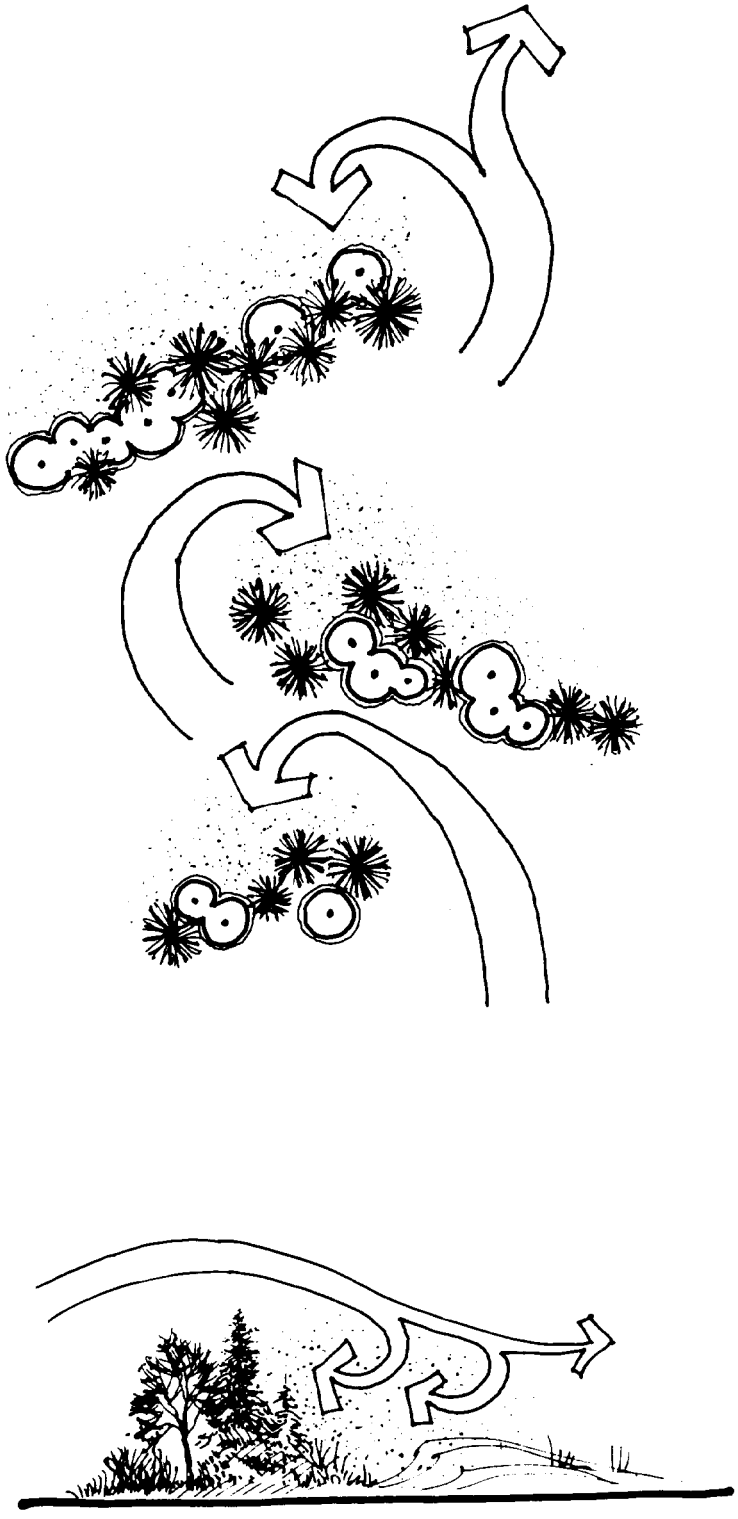


Figure 2-20. Snow drift control.

d. Temperature modification. Vegetation reduces the ambient air temperature by the cooling effect of transpiration (evaporation) of water through the leaves and by shading the ground. Vegetation covering the ground tends to stabilize temperatures by reducing extremes, whereas paved surfaces usually tend to increase temperatures in the surrounding air by reflecting absorbed heat. Shade trees are important for comfort practically everywhere in the United States. In all areas except genuinely subtropical and tropical areas, deciduous trees are best for this purpose because they furnish shade only during the summer and permit sun to penetrate in winter. Shade in parking areas may be introduced by planting large-growing trees about 40 to 50 feet apart. Trees which exude gummy substances or attract insects should not be selected for use in parking areas.

e. Glare and reflection. Glare from highly reflective surfaces or car headlights can cause visual discomfort. Plants can effectively soften glare and reflected light while adding to the aesthetic quality of an area. The degree to which plants are effective in absorbing and deflecting glare depends on their height, density and location (fig 2-21).

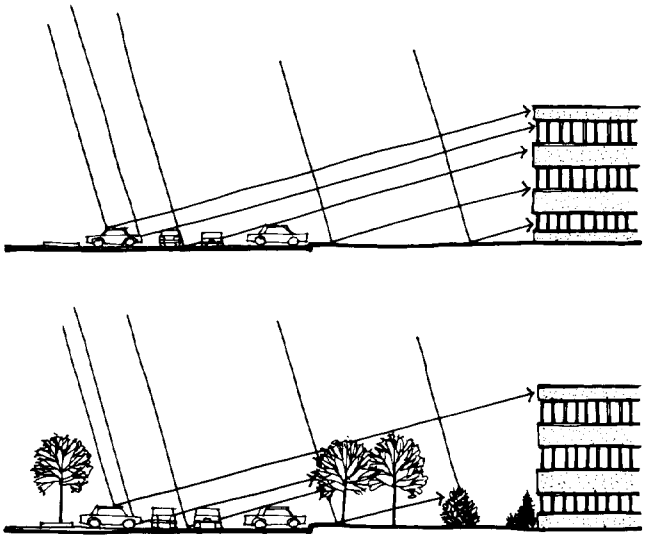


Figure 2-21. Glare and reflection control.

f. Erosion and dust control.

(1) Water is the most significant agent of soil erosion. The two basic types of water erosion are caused by splash and runoff. Splash erosion is best controlled by ground covers and leafy deciduous or evergreen plants. Runoff or sheet erosion is best controlled by grasses and other plants with very fibrous root systems. (fig 2-22).

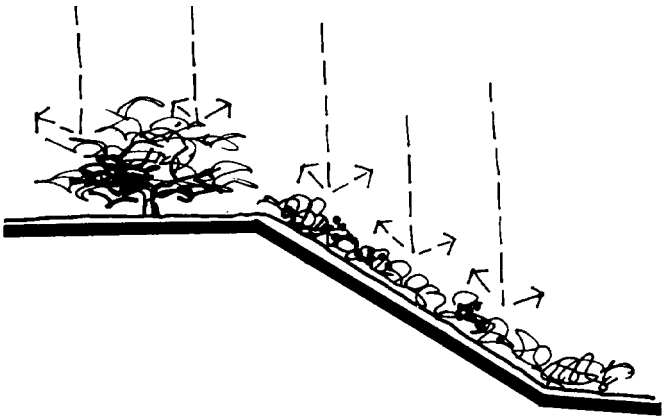


Figure 2-22. Erosion control—water.

(2) Plants can be used to control dust by providing wind barriers or stabilization for bare soil. Twiggy, dense-branching plants are effective as wind barriers. Ground covers, grasses and plants with fibrous root systems are most effective as soil stabilizers (fig 2-23). See TM 5-830-3/AFM 88-17 Chap 3, for specific guidance on dust control.

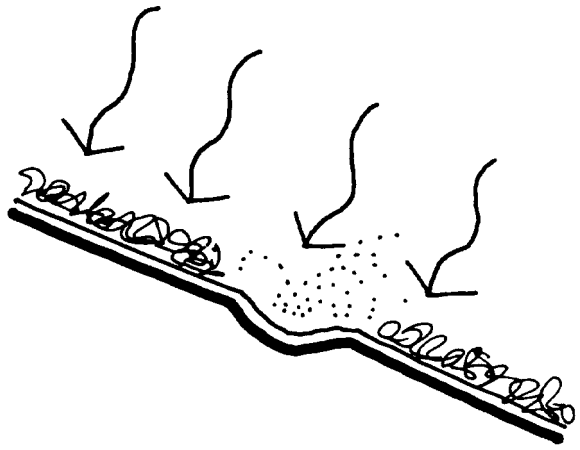


Figure 2-23. Erosion control—wind.

Section III. Design Process.

2-12. Process. A design process that includes conscientious analysis and design of the site, plant selection and development of design details should be employed to achieve the desired objectives of a planting program.

a. Site analysis. A complete site survey and analysis of existing conditions should be undertaken including an inventory of both natural and built features. Site factors of fundamental concern relative to both the retention of existing, as well as the installation of new, plant materials include:

— Visual factors.
— Climatic data.
— Existing vegetation.
— -Soils.
— Hydrology.
— Topography/slope analysis.
— Spatial analysis.
— Program analysis.
— Circulation patterns.
— Noise factors.
— Security requirements.
— Maintenance requirements.

b. Programming. Before a planting design is begun, development of a program is necessary. The program consists of a description of user requirements and environmental design objectives. User needs, environmental problems and maintenance capabilities should be carefully and thoroughly studied. In general, facilities in the 300, 500, 600 and 700 classes, as described in AR 415-28 and AFR 700-20, Volume 3, require some planting. The extent of the planting will vary with each class and with each category of facility within the class. The function and prominence of the facility should be the guiding factor in determining the scope of planting.

c. Conceptual design. After site analysis and program data have been evaluated, work on a conceptual design should begin. This involves arranging masses of plant material masses to satisfy the needs and requirements established by the site analysis and program. Plant masses should be arranged in terms of intended use and size rather than according to species or variety. The primary concern of the conceptual design phase is to provide solutions to the functional requirements of the site so that preliminary cost and phasing plans can be developed.

d. Specification of plant materials. After a satisfactory conceptual design is developed and adequate funding is assured, a final planting plan should be prepared. This involves translating the desired forms and sizes of plant masses into specific plant selections. A thorough knowledge of available plant materials and their characteristics is required.

2-13. Final landscape plan. The final landscape plan consists of a series of working drawings and a set of

specifications. These documents are used by the landscape contractor for bidding and constructing the project. Working drawings, with the exception of construction details, are based on a scale drawing of the site. The type and number of drawings required for a particular project may vary, but usually include the plans described below.

a. Planting plan. The planting plan shows the location and names of all plant materials. The following information about each plant species should be included on or with the plan:

— Common and botanical names.
— Size.
— Type of root preparation (i. e., container-grown, balled and burlapped or bare-rooted).

The required quantity of each plant should be indicated in the plant list.

b. Staking and layout plan. The locations of trees, shrubs, plant beds, hedges and other elements which pertain to planting are illustrated on the staking and layout plan. The exact location of each element is determined by measuring distances from established baselines or, in the case of very large sites, from coordinates of a grid system developed for the site.

c. Landscape grading plan. The landscape grading plan includes information for finish grading of lawns, berms and shrub beds. This plan should be coordinated with other grading and drainage plans for the project.

d. Irrigation plan. An irrigation plan should include the location, size and type of sprinkler heads, drip emitters, pipelines, manual or automatic valves and the water source and meter. Symbols for the various components of the system should be included. Detail drawings which illustrate back-flow prevention devices, system construction and assembly requirements or installation of various components of the system may be added to the plan.

e. Construction details. Detail drawings are used to clarify the construction requirements of various components of a landscape project such as paved landscape areas, retaining walls, footbridges, benches and fences. Detail drawings should include sizes and dimensions of materials to be used and, whenever necessary, construction techniques. Cross sections and elevations may be used to convey this information.

f. Specifications and cost estimates. Specifications for the project include technical data to support information contained in the working drawings and must coincide with information contained in existing military guide specifications. Cost estimates may be used for establishing a budget and a phasing schedule for construction of the project.

Section IV. Design Considerations

2-14. Objectives of landscape design. The overall objective of landscape design is to improve the physical and psychological well-being of people who live and work on military installations by enhancing their environment. Specific objectives are described below.

a. Preserve and enhance existing landscape resources. Existing trees, forest lands and detail planting features are important resources and visual assets that should be preserved and enhanced for functional as well as aesthetic reasons.

b. Improve overall visual quality. Aesthetic and functional applications of appropriate plant materials should be employed to improve the visual character of military installations. Plantings improve visual quality by:

— Harmoniously blending the built with the natural environment.
— Providing scale and comfort to the pedestrian environment.
— Visually reinforcing the hierarchy of the road network (see App B).
— Screening unsightly views or elements.
— Buffering incompatible land uses.

c. Improve the environmental quality of the installation. Better use should be made of plant materials to improve environmental quality and conserve energy. Plants can be effectively used in a variety of environmental applications including erosion control, air purification, noise abatement and climate modification.

d. Minimize maintenance requirements. Appropriate plant selection and detailing can minimize maintenance requirements while improving the visual quality of an installation.

2-15. Preservation of existing vegetation. For the general enhancement of developed areas, as much of the existing vegetation should be saved as is reasonably possible.

a. When the high cost of the extensive planting operations necessary to restore cleared areas is taken into account, complete clearing often cannot be justified. Costs of replacing existing vegetation should be weighed against costs of any special measures which must be taken for preservation. However, there are factors other than cost which must be considered, such as the time required to reestablish equivalent plant growth. Careful analysis may indicate that existing vegetation should be saved even if initial costs are higher. This is especially true in areas where immediate control of dust or erosion

is of prime importance. Limiting the extent of clearing and grading operations protects the environment and lowers construction costs.

b. Fast-growing trees regarded as weed types may comprise the predominant native vegetation in certain areas. Such trees are sometimes worthy of preservation until new ornamental plantings have matured, at which time the weed trees can be removed.

c. During site construction, minor variations in road and walk layout should be made to avoid damage to important vegetation.

2-16. Maintenance. Maintenance and its resultant costs may be kept to a minimum by coordinated planning. The design factors described below are essential for economical grounds maintenance and should be considered in the early design stages of a project.

a. Drainage. Good drainage of the surface and subsoil is necessary for successful plant growth and erosion control. Subsurface drains should be installed to correct conditions of excessive water retention in the soil. An alternative to subsurface drains, in some cases, is the selection of plants tolerant of wet conditions. Surface drainage in planted areas will be aided by proper grading. TM 5-820-4/AFM 88-5, Chap 4 contains further information concerning drainage.

b. Grading. Steep slopes are difficult and expensive to mow and maintain and are subject to erosion. Good grading design can often reduce the steepness of slopes. Slopes which must be mown should not exceed a grade of 3:1; top and bottom should be rounded to prevent erosion and facilitate mowing. Slopes steeper than 3:1 should be riprapped or planted with ground cover or other low maintenance plants which do not require mowing. Extensive grading should be avoided near existing trees; addition of deep fill or compaction of the soil within the drip-line can eventually kill the tree. Each site should be studied carefully to minimize grading and take maximum advantage of existing topography, vegetation and topsoil.

c. Detail planting. Flower beds and sheared hedges require a great deal of costly maintenance and should be used sparingly in selected locations. Where flower beds and sheared hedges are appropriate restraint in design can minimize maintenance.

2-17. Plant selection. Trees, shrubs, ground covers, vines and turf make up the palette used in planting compositions (fig 2-24). Selected varieties should be as few as necessary to satisfy the requirements and objectives of the design. By limiting varieties, clashing colors and forms are less likely to occur, and a unified composition can be created. In selecting plants for a specific project, growth characteristics must be considered. These characteristics are documented in landscape architecture literature, available through libraries, and government publications. Only those plants which can thrive with low maintenance under actual site conditions and produce the desired effect should be chosen. An investigation of plants growing at the project site and also at the oldest parks and cemeteries in the same general vicinity will suggest plants that may be used with confidence; plants found thriving under adverse conditions are likely to succeed with minimal maintenance. The ecological association of plants is an additional factor in plant

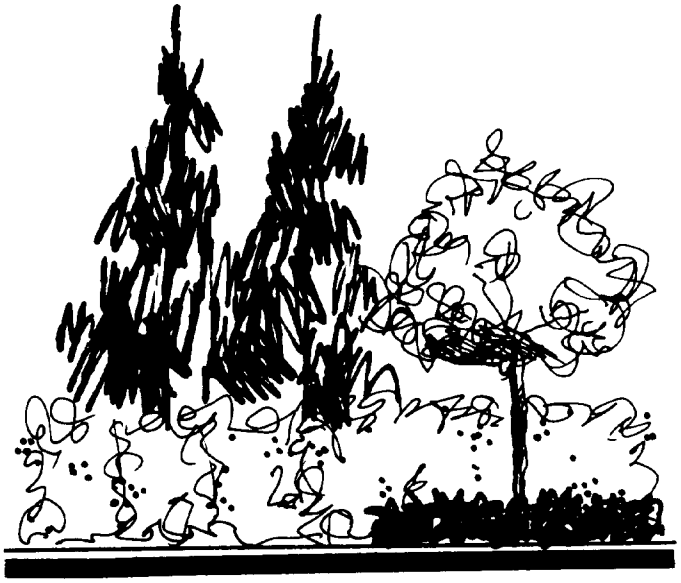


Figure 2-24. Palette of plant materials.

selection since plants naturally grow in groups requiring similar soil and climatic conditions. Other important plant selection factors are hardiness to temperature extremes; soil fertility requirements; ability to survive in very wet or dry soil conditions; the degree of tolerance for wind or salt air; ability to be transplanted; and resistance to insects and diseases. Recommendations on the selection of plants tolerant of specific site conditions can be obtained from the Agricultural Extension Service; Soil and Water Conservation District; or from federal, state, county and city park and forest agencies.

a. Trees and shrubs. To achieve maximum visual and functional effectiveness with minimum maintenance, emphasis should be placed on the use of trees instead of the extensive use of shrubs. Properly selected trees will be less expensive to maintain than shrubs and have greater visual impact on the landscape. Simple and effective planting designs can be achieved with trees, lawns and a limited use of shrubs.

b. Evergreen and deciduous. Deciduous trees offer a wide variety of effects because of seasonal changes, flowers, berries, fruit, and color and texture of bark. Evergreen trees and shrubs provide green color during seasons when deciduous plants are leafless and adds permanent structural value to the landscape. The areas of the country where evergreen plants are not readily available, deciduous ones may be used for a greater part of the planting, with evergreens used only at focal points in conjunction with important features and structures.

c. Vines. Vines must be carefully selected. Many vines climb by means of tendrils, disks or root-like hold-fasts which can damage wood or masonry walls. Maintenance and repair work can be difficult and costly if vines must first be removed. Generally, vines should be restricted to fences, trellises and structures other than buildings.

2-18. Irrigation Systems.

a. Basis for requirement. Irrigation requirements depend on several factors. In selected areas, it may be necessary to use irrigation to promote the healthy and attractive growth of turf. The use of drought-tolerant ground covers, gravel or rock mulch will minimize the need for irrigation systems. However, in some cases, the location, importance or use of an area makes the substitution of alternative ground covers undesirable. Irrigation requirements depend on several factors:

— Precipitation deficiency.
— Soil’s water holding capacity.
— Seasonal distribution of rainfall.
— Quality of turf to be maintained.

Irrigation should generally be provided in arid and semi-arid regions to enhance the quality of turf, even though lawns or other grasses may survive without irrigation. Supplemental irrigation may be needed in subhumid and humid regions where many adapted non-native grasses tend to become dormant during periods of drought.

b. Design factors. The following factors should be evaluated when designing an irrigation system:

— Availability and accessibility of existing water supplies, including non-potable sources.
— Amount of water required, as determined by type of turf to be irrigated, climate, terrain and soil conditions.
— Budget.

TM 5-630/NAVFAC MO-100.1/AFM 126-2 provides further guidance for the design of irrigation systems.

c. Types of systems. The use of pop-up systems is justifiable in arid and semi-arid regions where frequent irrigation is required. Quick-coupling sprinkler systems are mainly used for areas where only supplemental irrigation is necessary. Where pop-up spray systems are used, automatically controlled, clock-timed systems are recommended to save labor and facilitate non-peak water use. Hose bibs on building exteriors may be used for limited irrigation and hand-watering. Any irrigation system, either hand-watering or automatic pop-up systems, should be based on a feasible irrigation schedule in terms of hours per day or per week.

d. Project justification. Projects using either pop-up or quick-coupling sprinkler systems must be justified on the basis of amortization and operating costs. An analysis should include:

— Estimated precipitation deficiency on an annual basis and for the summer season (June through August).
— Acres of installation grounds currently irrigated by underground systems and all other means (hose bibs, flooding or portable systems).
— An analysis of the system's impact on water usage rates, especially during peak usage periods, in relation to current installation water resources.
— A discussion of any soil factors or turfgrass management conditions affecting the irrigation requirement.

e. Sewage plant effluent. Sewage treatment plant effluent may be used for irrigation wherever feasible. In addition to the justifications and information considered in the proceeding paragraphs, answers to these questions should be provided:

— Is there enough effluent available to support both short and long-term irrigation needs?
— Is the proposed irrigation distribution system isolated from existing distribution systems for potable water supplies?
— Will site-users have direct contact with irrigation water?
— Will Federal, state and local health requirements be met?

f. Planting design in arid areas. Landscape designs, plantings and irrigation systems in arid regions should be appropriate to the natural environment. Careful water management is the key to making an arid landscape succeed. Characteristics of a water-conserving landscape are:

- — Overall reduction of turf area.
- — Turf used only in large, level areas to provide for better irrigation efficiency.
- — No turf planted within drip-lines of trees, along narrow paths or median strips, or adjacent to foundations.
- — Buildings clustered around the periphery of green "oasis" areas.
- — Drought-tolerant plants used whenever turf is not used.
- — Moisture-loving plants confined to drainage areas where water naturally accumulates or to "oasis" areas.
- — Grouping of plants with similar irrigation requirements. For example, plant species may be grouped in zones that radiate outward from the building and require progressively less water as the distance from the building(s) increases.
- — Restriction of turf and other moisture-loving plants to entrances or focal points of buildings. This technique localizes areas of frequent water use. The lush greenery near the building contrasts with the drier landscape further away from the building and serves to identify areas of major use on the installation.

CHAPTER 3

PLANTING AND ESTABLISHMENT OF TREES, SHRUBS, GROUND COVERS AND VINES

3-1. General. In this chapter, guidelines, standard practices and techniques for planting and initial care of trees, shrubs, ground covers and vines are discussed. Adherence to these guidelines should result in the successful establishment and healthy growth of plantings. Criteria for selection of plant materials and each step necessary to implement the planting plan are also described.

3-2. Planting seasons. In most parts of the country, the most favorable time for planting is during the inactive, or dormant, period of the plant's cycle. There are certain geographic areas, generally in warm regions, where plants may be moved at almost any time of year. However, even in these areas plants have definite growing cycles. Moving the plant during its active growing period should be avoided whenever possible. Often, the extra stress resulting from moving plants during the wrong season causes them to remain in a weakened condition, showing little or no leaf growth until the following growing season. There is extra expense involved in planting out of season because plants must be handled more carefully and watering must be extended for a longer period. Advice on recommended planting periods for a particular geographic area can be obtained from a County Extension agent, Soil and Water Conservation District office, or state, county, and city park or forest agencies. When moving plants out of season, an anti-desiccant should be used. Anti-desiccants are chemicals which protect plants from excessive moisture loss, thereby reducing shock during transplanting. Anti-desiccants also aid in the prevention of winter-kill, summer scald and disease. The spraying of liquid anti-desiccant on the foliage prior to digging the plant from its original location allows planting or transplanting operations during active growing periods. The most favorable periods for planting are as follows:

a. Temperate zone. Deciduous plants may be moved in the fall after leaves drop but before the ground freezes, or in the spring after the ground thaws but before new leaves appear. In areas with cool summers, evergreens are best planted in the late summer after new growth has hardened-off, or somewhat later in the spring than deciduous plants. Farther south, in the temperate zone where the ground seldom freezes, deciduous plants may be moved whenever they are leafless; evergreens should be moved during the same period.

b. Sub-tropic zone. In sub-tropical areas, no definite planting periods exist and it is possible to move most plants with fair success whenever they are not in a period of vigorous growth. Palms and bamboos are most easily handled in early summer. Oaks, including Live Oaks, are difficult to transplant except during the winter when they are relatively dormant. Even in the subtropics, much is to be gained by planting during cooler months unless plants are container-grown or otherwise handled with special care. For instance, collected wax myrtles planted during hot weather require heavy pruning and usually put out little foliage before the following spring. Planted in winter or spring, wax myrtles will establish easily and will not require much pruning.

3-3. Quality of plants. The most important step in assuring successful planting is to select plants of the highest possible quality. Widely accepted criteria may be found in the American Association of Nurserymen publication, "American Standard for Nursery Stock", ANSI Z60.1. High quality in plant materials is achieved through nursery practices which produce plants with desirable branching characteristics and root systems that are conditioned for successful transplanting. The ANSI standards are accepted throughout the landscape industry and by government agencies. Several additional common sense rules should be applied in selecting plants. Plants should be grown or collected from an area having a climate similar to that of the planting site. This improves the chances for plants becoming established in the new location. Collected plants are often inferior nursery-grown plants in both appearance and ability to survive transplanting because normal nursery practices, such as pruning of tops and roots, fertilizing and cultivation, have not been applied. Collected plants usually have widely branched root systems due to lack of root pruning. Consequently, a large proportion of the root system is lost in transplanting. Collected plants should not be used unless qualified personnel conduct and direct the operation and a lower grade plant is acceptable. No plants, whether nursery-grown or collected, should be considered acceptable if they have bruised bark, broken primary limbs, unbalanced growth, off-color foliage, insect infestation or diseased wood. Plants infested with insects or disease are especially undesirable as they are potentially contagious to nearby vegetation. Any of the above-mentioned characteristics indicate inferior plants

and give rise to future problems during the establishment period.

3-4. Handling and transportation. During handling and transportation, it is important that roots remain moist and tops are not subjected to the drying effects of sun and wind. Scarcely any plant will survive if its roots have once been dried out; most plants are seriously set back by the drying of even the fine root hairs. Exposure of the tops to wind and sun places a demand for extra moisture on plants which cannot be met while the plant is out of the ground; serious injury often results. Moisture can be retained by spraying the branches and foliage with an anti-desiccant prior to digging and by loosely covering the tops. Bare-root plants should be protected from moisture loss by loosely wrapping the roots in wet burlap immediately after they are dug. Care in handling and transportation shortens the time required for plants to become established in a new location.

a. Handling. Other factors being equal, plants grown in containers and removed carefully, so that the root-ball remains intact, start new growth most rapidly. Plants moved with solid, natural balls of earth enclosing most of the roots also recover fair rapidly. Plants moved with bare roots recover more slowly than those handled by the other two methods. The most common methods of handling are described below.

(1) *Container* grown *plants.* Healthy young plants, grown in containers offer ease of handling and better storage life, and they start new growth more rapidly.

(2) *Balled and burlapped plants.* The use of balled and burlapped plants allows for the transplanting of more mature and larger plants to produce an immediate landscape effect. The balling and burlapping operation should be performed under the supervision of trained personnel. The cost of moving plants with natural earth balls is considerable, but this method is the only way to move some types of plants successfully. Plants handled in this manner require less severe pruning, become established more rapidly and need less attention during the establishment period than bare-root plants. Tree spades are designed to dig and trans- port trees without disturbing the roots. There is no need to wrap the rootball since it is contained by the metal plates employed in digging. Use of tree spades is generally restricted to short-haul operations and can produce highly satisfactory results particularly when plants are large and must be moved out of season.

(3) *Bare-root plants.* Plants may also be removed from the ground bare of soil. This is a common practice, especially for small deciduous and seedling evergreen trees. This method should not be used except during the plant's dormant period. Large plants, especially deciduous ones, dug with bare roots require heavy pruning of tops to compensate for the loss of roots and rootlets. The shock of bare-root transplanting is more severe than with other methods and recovery time is longer. Coating roots in very wet clay (puddling) or wrapping them in wet burlap immediately after digging will prevent roots from drying out.

(4) *Collected plants.* Collected deciduous plants can be moved either balled and burlapped or bare-root; except for seedlings, evergreen plants should always be balled and burlapped. Regardless of the method used, collected plants should be root-pruned in place at least one growing season prior to transplanting and plainly tagged for ease of identification.

(5) *Existing vegetation.* The possibility of transplanting existing vegetation should be given careful consideration when making planting plans. Whenever possible, plants to be moved should be root-pruned well in advance of the growing season.

b. Transportation. On or before delivery, plants should be inspected for correct size, type and quantity. They should be examined for damage, insects and wilting. The plants should have no unsightly irregularities and be in satisfactory condition. Plants dropped over the side or off the tailgate of delivery trucks should be rejected, as damage to the root system is highly probable even though it may not be apparent. Delivery should be coordinated with planting operations to avoid prolonged storage on the site. Bare-root plants should be given planting priority because they are most vulnerable to moisture loss. The shorter the time a plant is out of the ground, the better its chances for survival. If it is not possible to plant on the same day as delivery, storage in a protected area and additional watering are necessary.

3-5. Soil and additives. The guidelines in this chapter concern soil and additives for the planting of trees, shrubs, vines and ground covers. More often than not, soil available at the planting site will not be wholly satisfactory for vigorous growth and must be improved by the addition of various materials.

a. Soil. Whenever available, soil for backfilling plant pits or beds should be friable (easily pulverized), fertile topsoil that has a demonstrated capability of sustaining vigorous plant growth. The topsoil should be of a uniform composition, containing no subsoil, twigs, clumps of grass, stones or hard shale larger than one inch, toxic substances or other extraneous material. Soil meeting these general qualifications is usually adequate to sustain healthy plant growth. Good quality topsoil previously stripped from the site and stockpiled prior to grading operations may be used; topsoil from another site located in the general area of the planting project is also acceptable. Stripping of topsoil should be done carefully to avoid stirring up subsoil and mixing it with topsoil. Topsoil to be used should be tested for soil acidity (pH) and organic content by a qualified testing laboratory.

Local agencies such as the State Agricultural Experiment Station, County Extension agents, Soil and Water Conservation District, state university or qualified private organizations may be contacted for information about laboratory soil tests. The laboratory test report will include specific recommendations on materials required to bring the soil to acceptable levels of acidity (pH) and organic content.

b. Additives. Various materials may be needed to improve substandard soil, but precautions should be taken in their use.

(1) *Soil conditioners.* The addition of soil conditioners improves the friability and, except for sand, the moisture-retaining capacity of the soil. Humus (peat), spent manure, sand and commercially available minerals such as vermiculite and perlite can be mixed with planting soil. As a general rule, a mixture of one part sand or mineral soil conditioner, one part humus and one part topsoil will provide a Soil mixture suitable for planting trees and shrubs.

(a) Sand and minerals. Coarse sand and minerals such as vermiculite and perlite are especially useful for making heavy clay soils more friable. Since none of these soil conditioners contain plant nutrients, they should be supplemented with fertilizer. Sand is usually the most readily available and inexpensive material, but is much heavier than mineral conditioners. Vermiculite and perlite are light in weight and should be used for planter boxes or roof gardens where structural load is a significant consideration.

(b) Humus. Humus, in the form of peat moss, rotted sawdust or spent manure, can be added to the soil to provide organic matter and promote healthy plant growth. If peat is not readily available, any decomposed vegetable compost can be used. If the cost of adding commercial humus (peat) to the soil is too high, acceptable results often can be obtained by use of more economical and locally available sources of organic material.

(2) *PH adjusters.* The need for pH adjusters may be indicated by the laboratory test report and recommendations. The pH scale for most soils ranges from 4.0 (strongly acid) to 10.0 (strongly alkaline) with 7.0 being neutral. Most plants absorb nutrients best from soils between pH 6.0 to pH 6.5, whereas lawn grasses thrive at pH 6.5 to pH 7.0. Ericaceous plants are acid-loving and prefer soil which tests at about 6.0. If available soil varies radically from acceptable levels of acidity or alkalinity, pH adjusters can be used. Correct measurement and thorough mixing are essential when adding these materials. Too much acidity in the soil is as harmful to plants as too much alkalinity, even for such ericaceous, broad-leaved evergreens as azaleas and rhododendrons. Lime and sulfur are the most commonly used pH adjusters.

(a) Lime. The addition of lime to the soil reduces acidity. Many woody plants are somewhat tolerant of soil acidity and require no pH adjustment. However, some ornamental plants may require that an alkaline soil condition be maintained. Advice on correct amounts and times for liming can be obtained from a reliable local nursery or County Extension agent.

(b) Sulfur. If soil tests reveal that the soil is too alkaline, it is generally good practice to add sulfur in the form of commercially available, acid-producing compounds. Aluminum sulfate is the most readily available source of sulfur. Again, as with lime, advice should be sought concerning the quantity of chemicals which should be added to achieve the desired pH.

(3) *Fertilizers.* The use of fast-acting fertilizers in the soil mixture at planting time is of little value since plants are not able to use plant food effectively until they become established. Highly soluble plant food may leach away before the plants have recovered sufficiently to use it. In fact, the use of fast-acting fertilizer in the soil at planting time may actually burn or damage plants. It is more effective and safer to use slow-release fertilizer pellets in the soil or to top-dress plant pits and beds with a moderate amount of fertilizer at the time of planting.

(4) *Soil wetting agent*. The addition of a commercially manufactured soil wetting agent increases the ability of heavy clay soils to absorb water. Such an agent is especially useful in large plant containers for increased moisture penetration prior to transplanting. Although the cost may be justified in limited areas such as planter boxes, these wetting agents are not recommended for large scale use. Wetting agents may be applied as an additive dissolved in water or in granular form as part of the planting soil mixture.

3-6. Drainage. Most plants will not survive if the soils surrounding them remain saturated, because roots cannot absorb oxygen and the plants will suffocate. Excess soil water becomes stagnant and the roots of newly set plants often rot. Surface or subsurface drainage must be provided to collect and carry away excess water since most plant species are not capable of enduring prolonged periods under wet soil conditions. Some plants, such as willows, grow better under these circumstances, but they are few in number. Newly set plants are more susceptible to suffocation from excess water than well-established plants. Collection of excess water may be accomplished by either of the methods described below.

a. Surface drainage. Surface drainage in swales or ditches is the most common means of collecting water and providing positive drainage. This method is more economical than subsurface systems. When drainage swales or ditches must be crossed by pedestrian or automobile traffic, it is better to provide subsurface systems. Swales and ditches are difficult to maintain if banks

are too steeply graded.

b. Subsurface drainage. Subsurface drainage systems are the most permanent and effective means of collecting excess water from plant pits and beds. Subsurface drainage systems may consist of French drains, open-joint agricultural tile, perforated agricultural tile or perforated plastic pipe. Collected water can be channeled to a retention pond or dry-well, to the surface by exposing the outlet at a low part of the site, or to a storm sewer system (fig 3-1)

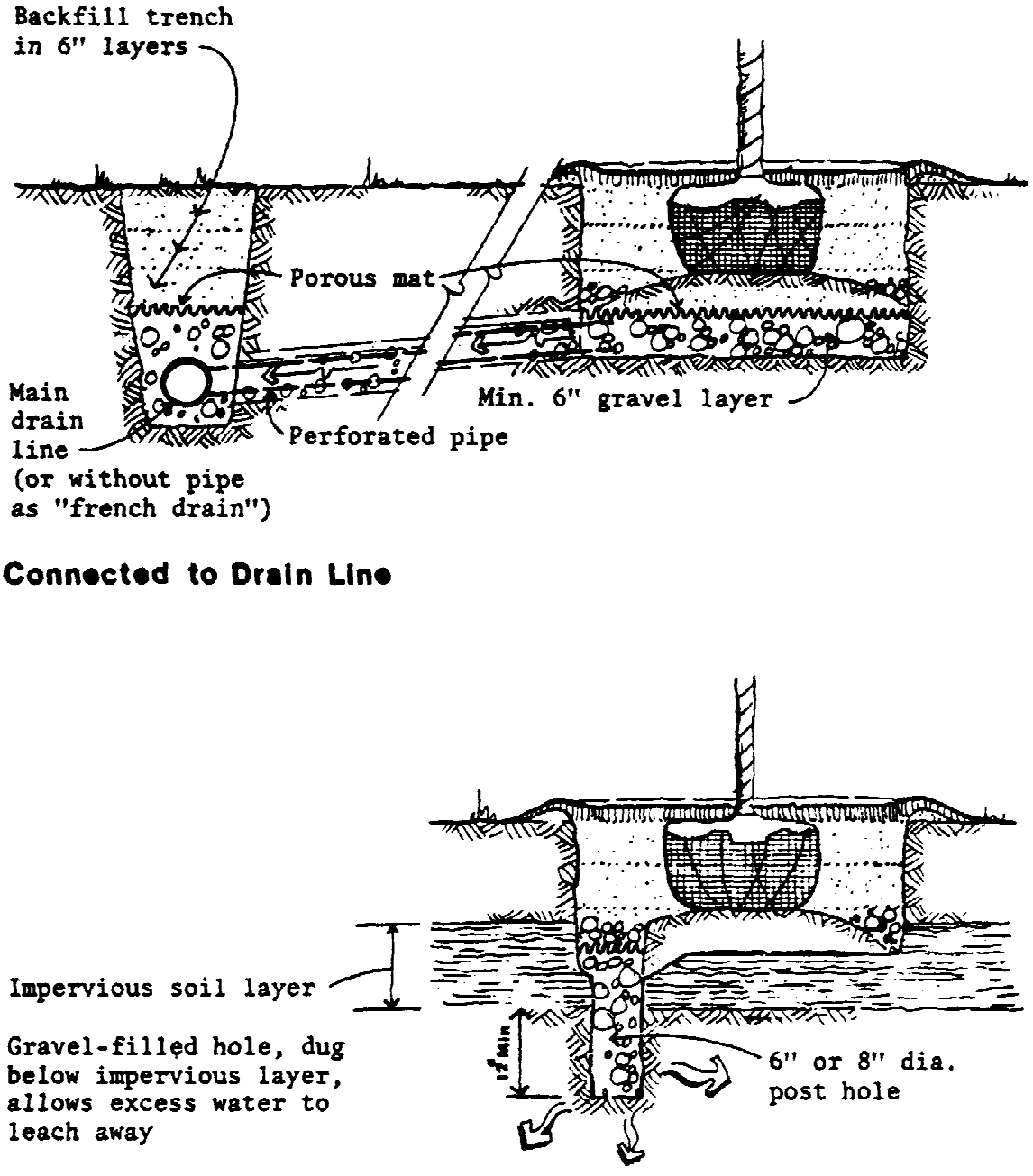


Figure 3-1. Subsurface drainage of plant pits and beds.

3-7. Planting operations. High quality plants, carefully transported and transplanted immediately with adherence to the procedures described below, will usually become established quickly in their new environment.

a. Storage of plants on the site. Plants not planted on the day of arrival at the site should be placed in protected areas and kept moist to prevent drying of roots and tops.

b. Plant Pits and beds. Plant pits and beds should be prepared prior to delivery of the plants to permit immediate planting. Tree pits should be two feet larger than the diameter of the earth ball or the maximum spread of the roots and six inches deeper than the vertical dimension of the earth ball or the maximum depth of the roots. Pits or trenches for shrubs should be dug only one foot wider than the spread of the roots, the diameter of the earth balls or the width of the container and six inches deeper than the vertical dimension of the earth ball container or depth of the roots. If the excavated soil is suitable, it may be used as backfill around the roots or the earth ball. Otherwise, the soil should be removed from the site.

c. Placement of plants. Figure 3-2 illustrates proper planting methods and placement for various types of plants. Generally, plants should be set at such a level that, after settling, they will maintain their original relationship to the ground surface, as indicated by the visible soil line at the base of the trunk. In some cases, plants are set slightly higher or lower than the original ground line to accommodate certain climatic or soil conditions. For example, palms are frequently planted considerably lower in loose, sandy soil for stability in windy locations or to reach a low water table. Most plants, however, cannot tolerate being planted too low and will die if their root crowns are smothered by being covered with excess soil. When planting large trees in recently filled areas where settling is likely to occur, the tree should be placed slightly higher than the surrounding soil. In due course, it will settle and assume its correct relation to the surrounding ground surface. Sometimes, where water tables are high and normal drainage of pits and beds is difficult or uneconomical, trees and shrubs may be planted in earth mounds. However, the relationship of the soil level immediately above the plant's root system should remain as it was prior to transplanting. Planting soil should be prepared and moistened prior to placing plants in the pits or beds. Dry soil should not be used as backfill, but if this is unavoidable, water should be kept running into the pit or bed to saturate the soil and settle it around the roots after planting.

(1) *Setting plants.* Backfill soil should be mounded in the bottom of the pit or bed and tamped to minimize settling and allow firm placement of plants. Each plant should then be held in a vertical position and turned to take advantage of its natural characteristics for best appearance in a given location.

(2) *Future watering.* To facilitate future watering, a saucer-shaped depression should be formed in the soil around individual plants. Where trees are planted in an area surrounded by paving, at least one vertical watering tube should be placed during backfilling to permit watering of the root system. Watering tubes can be 4-inch agricultural tile, 4-inch perforated plastic pipe or 4-inch perforated metal pipe filled to the ground surface with coarse, washed gravel.

d. Pruning. Pruning should be limited to the amount necessary to compensate for the portion of the root system which has been lost during transplanting operations. Evaporation of moisture through the leaves must be reduced to balance with the smaller intake capacity of the roots. If too much moisture is lost, the plant will die or lose its leaves. If defoliation occurs quickly and the leaves do not dry up slowly and hang on, the chances are very good that the plant will send out new leaves after the root system has begun to recover. A safe practice is to cut back the branches of deciduous plants approximately one-third. Pruning of the secondary branches should maintain the natural shape of the tree. The tip end of a tree's main vertical stem or trunk, the leader, should never be cut as this may result in a radical change in the natural growth pattern. Broken and frayed roots should be cut off cleanly above the injuries to minimize the possibility of decay. It is not usually necessary to prune evergreen material at the time of planting, but local practices should be followed. The proper method of pruning is to use well-sharpened equipment to make clean cuts. The pruned surface of branches over one inch in diameter should be treated with commercial tree paint (fig 3-3).

e. Tree wrapping. The trunks of deciduous trees over two inches in caliper should be wrapped with high grade burlap or a commercially prepared tree wrapping paper immediately after planting. The wrapping material should be wound spirally upward around the trunk to the second major branch and secured. Wrapping retards evaporation and prevents sun scald and splitting of the bark.

f. Guying and staking. The primary purpose of guying and staking trees is to prevent excessive movement of the trunk, thus keeping new, fibrous roots from breaking their hold in the surrounding soil. Artificial support is especially necessary for trees with slender, weak trunks, for unusually large shrubs and in areas with adverse wind conditions.

(1) *Methods of Guying.* Trees up to about 5-inch caliper will usually require three guys, each consisting of two strands of 12-gauge wire attached to the tree trunk in such manner as not to injure the bark, and tied at the ground to heavy stakes (deadmen) or commercially available anchors. The bark should be protected from

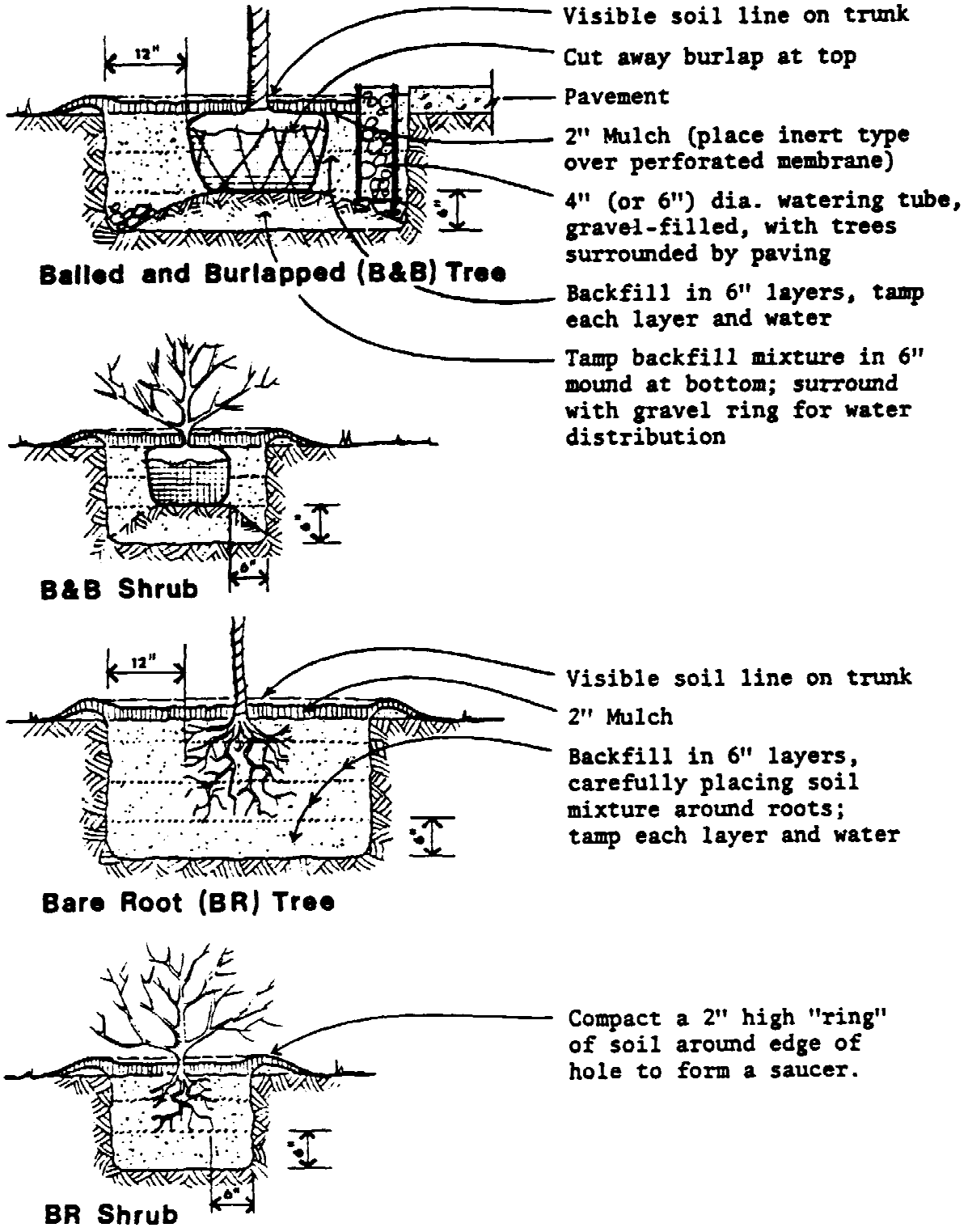


Figure 3-2. Planting methods.

Pruning must be done in a manner which preserves the natural form of the tree or shrub.

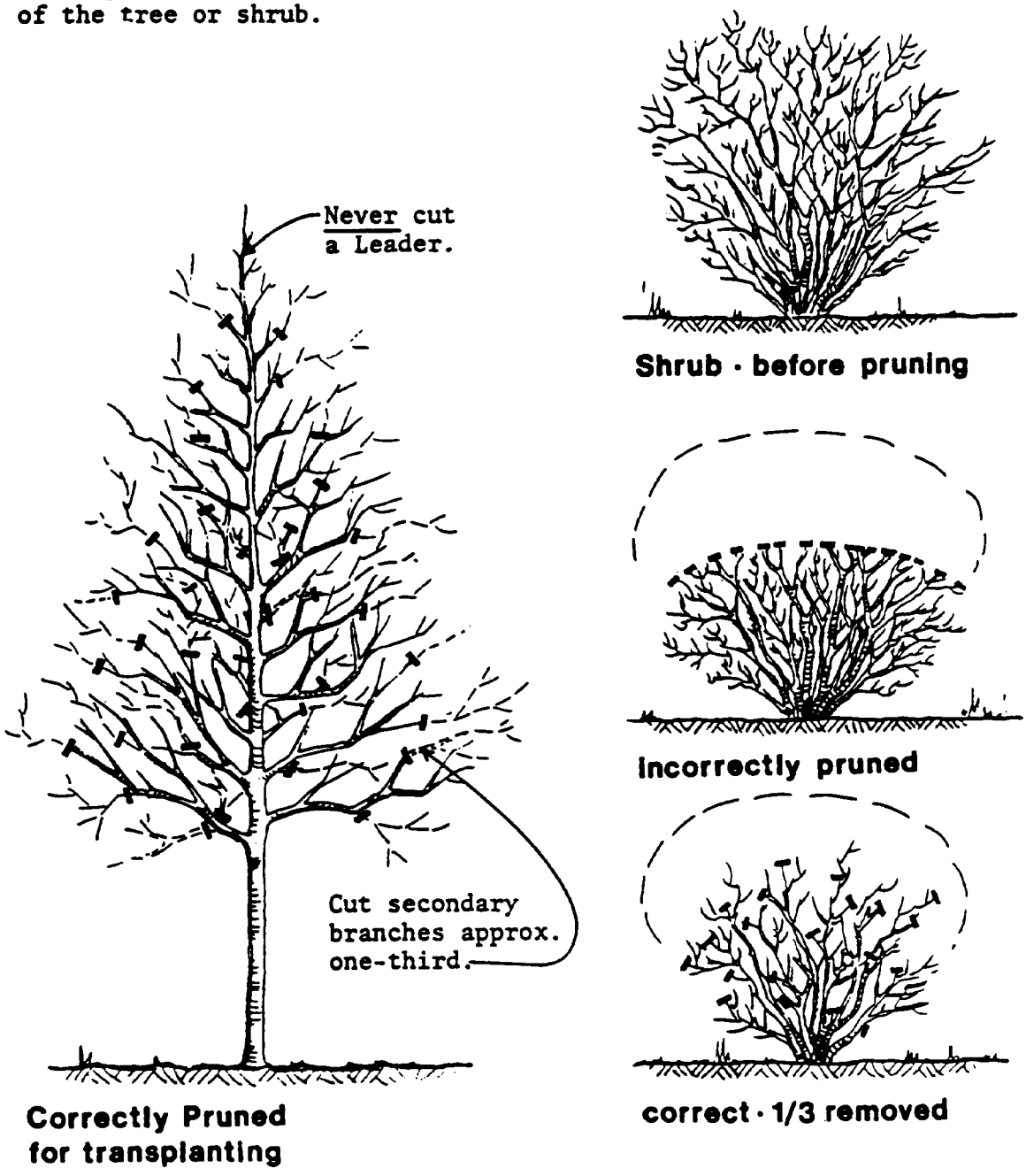


Figure 3-3. Pruning.

serious injury by using short lengths of garden hose to sheath wire. Guys may be tightened by inserting a small piece of wood between them and twisting the two stands of wire together or by the use of turnbuckles. Guying of trees over five inches in diameter may require the use of four guys and more than two strands of wire for each guy, or wire heavier than 12-gauge. In lawns and near paved areas, guys may present a considerable inconvenience or an actual hazard, and colored flags should be tied to them (fig 3-4).

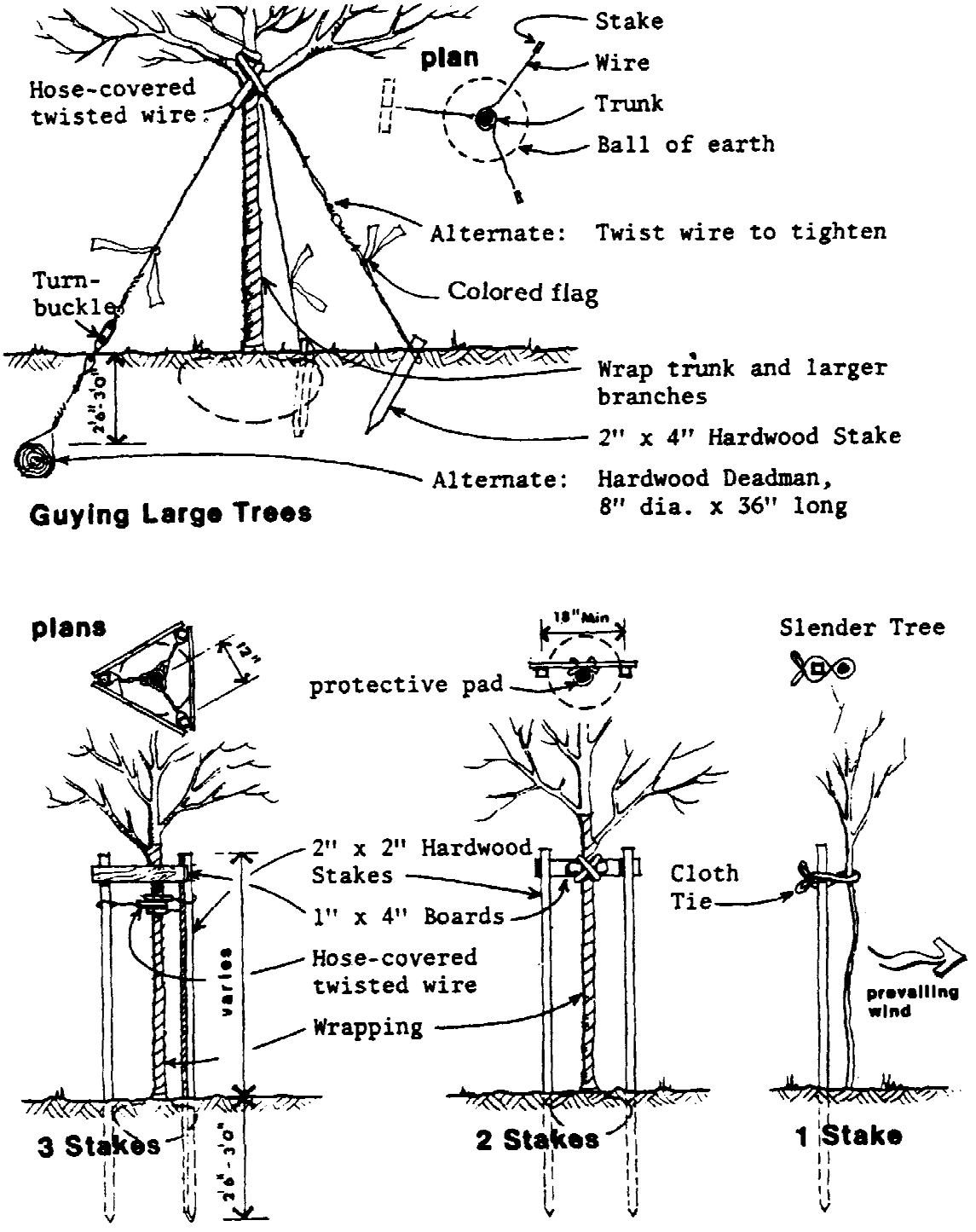


Figure 3-4. Guying and staking.

(2) *Methods of staking.* Staking will furnish adequate support for trees up to about four inches in diameter. A good staking method is to use three 2- by 2-inch stakes, each about 9 feet long, or the equivalent in round natural poles, driven about 1 foot from the outer edges of the root ball in an equilateral triangle to a depth of 2 to 3 feet, and connected at the tops by 1- by 4-inch nailed-on-top braces. Alternate staking methods include the use of two stakes connected to the trunk by 12-gauge wire sheathed in garden hose. When using less than three triangularly-placed stakes, particular attention should be given to the direction of prevailing winds.

(3) *Securing evergreen trees.* Evergreen trees up to **6** feet in height usually do not need support. One stake placed on the windward side of the tree normally will suffice if support is required. Evergreen trees between 7 and 12 feet in height should be guyed and anchored as outlined above for deciduous trees up to 5-inches in caliper. Evergreen trees higher than 12 feet should be guyed and anchored as outlined above for deciduous trees over 5-inches in caliper.

g. Mulching. Mulching is well worth its cost under most circumstances, because it promotes growth and recovery and reduces the frequency of weeding and watering. Mulching retains moisture in the area around plants by adding a loose-textured surface covering that gives shade to the ground beneath and reduces loss of water through evaporation. In colder climates, mulch protects plants from the injurious effects of frequent freezing and thawing. Where stable materials such as shredded bark can hold the soil in place, mulching is a valuable aid for erosion control. Mulch material should be placed over the entire plant pit or bed. Depth of mulch will depend on the material used. Mulches are classified in two principal categories depending on their origin. The first, and most widely used, is organic mulch; the second type is inert, or inorganic. Frequently, mulch is used to add aesthetic appeal to planting areas.

(1) *Organic mulch.* One or two inches of shredded bark will give results equal to four or five inches of marsh hay. Forest litter, wood chips, and, in some localities, industrial by-products such as cocoa bean hulls, nut shells, ground-up corn cobs, rotted sawdust and other organic materials are effective mulches. If fresh sawdust or green vegetative mulch is used, 7.5 pounds of ammonium sulfate or its equivalent should be uniformly mixed into each cubic yard of mulch. This will aid bacterial action and provide nitrogen for the natural decaying process in the sawdust. Otherwise, plants may suffer from lack of nitrogen.

(2) *Inert mulch.* River bank stone, crushed rock, granite or marble chips are visually effective, but a high level of maintenance is usually required to keep the plant pit or beds weed free. Use of a plastic membrane under the inert material is not recommended. Such inert mulches should not be used unless specifically called for on the planting plan, because their use is often a design decision. This is particularly true when colors of gravel or marble are specified.

3-8. Establishment. Maintenance after planting should be frequent and thorough so that no period of neglect will endanger the successful establishment of the plants. During the establishment period, many plants may exhibit abnormal symptoms such as defoliation, off-color foliage, smaller than normal leaves, or lack of flowers or fruit. Sufficient time should be allowed for plants to recover from the trauma of being transplanted. The condition of new plantings should be checked during regular and frequent inspections. The following items should be checked and corrected as needed:

— Do plant beds need water?
— Do plant beds need to be weeded?
— Is there any sign of disease, insect, animal or storm damage?
— Do plants need additional pruning?
— Is mulch in good condition?
— Are guy wires secure?
— Are protective hoses in place around the trees where wires are attached?
— Is tree wrap securely in place?

Maintenance during the establishment period includes watering, weeding and cultivating, fertilizing, control of diseases and insect pests, protection from damage by small animals and pruning, all of which are described below.

a. Watering. Lack of water immediately after planting is extremely dangerous because the reduced root system has difficulty in supplying sufficient moisture to the plant. If the roots are allowed to become too dry, the plant will die. When planting is done during warm weather, the danger is most acute. Planting in the late fall in northern regions is usually successful if plants are heavily watered at the time of planting. In most regions, periodic watering will be required until the plants are firmly established, at least one year after planting. Rain cannot be depended on to supply sufficient moisture to maintain a new planting.

(1) *Sources.* A satisfactory source of water should be determined well in advance of any planting operation. Except in housing complexes and other developed areas, watering from ordinary hose connections may not be feasible. Possible sources of water in undeveloped areas include use of water tank trucks or pumping water from nearby ponds, streams, or wells through portable pipes, canvas hoses, troughs or temporary ditches. In arid regions, permanent underground irrigation systems may be justified. Technical assistance should be sought if such a system is considered feasible and economical.

(2) *Frequency and method.* Soil should be examined regularly and frequently to determine when watering is needed. In warm, dry weather the soil in a new planting can dry out in a surprisingly short time. Water should be applied immediately if soil is dry to the touch a few inches under the surface or if the leaves of plants are wilting. Watering should be thorough and frequent enough to assure that the root zones remain moist during the establishment period. Root balls serve as small reservoirs of available moisture until new roots can draw water from the surrounding soil. To keep moisture from being drawn out of the root balls into dry surrounding soil, water should be applied slowly and allowed to soak into the ground until the surrounding soil reaches field capacity without runoff. This procedure promotes deep root growth, which enables the plant to withstand dry periods and accelerates establishment.

b. Weed control. The area in and around newly-planted trees, shrubs, ground covers and vines should be kept weeded so that plants will not suffer from competition for moisture and plant nutrients. Mulching, as previously mentioned, is highly effective for reducing weed growth and evaporation of soil moisture. Mulch should be maintained at the same depth as when initially placed in the plant pits and beds.

c. Fertilizing. Nitrogen, phosphorus and potassium are the three chief chemical elements required by plants to produce healthy top and root growth. These elements are present in varying amounts in most soils and form the basis for all fertilizers. When plants become established in areas approximating natural conditions, with fallen leaves remaining around them, these elements are returned to the soil and provide adequate natural fertilizer. If plants are surrounded by pavement or located in an area where leaves are raked and removed, there is no natural recycling of chemical elements and they must be replaced periodically by fertilizing. The proper time to begin fertilizing will vary for different kinds of plants and growing conditions, but it is seldom beneficial to begin applications of commercial fertilizers earlier than 6 months after planting. The type, amount and frequency of fertilizer application should be determined on the basis of soil conditions and the size and variety of plants involved. The most effective application method is by means of a grid of holes punched in the root zone, rather than by surface application, so that both shallow and deep roots are reached as quickly as possible without harming surface feeding roots. In general, fertilizers containing a large proportion of phosphorus are desirable because they promote root growth. Slow-acting fertilizers are preferable to fast-acting or soluble fertilizers that leach away rapidly. Fertilizer dissipates more rapidly in highly porous soils. Therefore, applications in sandy soils should be small and frequent. The best time to fertilize is shortly before a natural growing season. Plants should not be forced into lush grow by application of fertilizer during the latter part of a growing season because tender new shoots are more vulnerable to freezing temperatures. Specific recommendations on fertilizers and application methods can be obtained from a local Agricultural Extension agent, state university, Agricultural Experiment Station or similar source.

d. Control of insects and diseases. If plants have been selected with regard to their natural resistance to local insects and diseases, control of infestations will generally be simplified. Planting and maintenance procedures described in this manual will also provide healthy growing conditions which reduce susceptibility of plants to infection. If insect infestation or disease damage occurs, remedial measures should be taken at once. Professional help should be obtained to identify the problem and recommend specific treatment. Depending on the type and size of the affected plant, it is sometimes more expensive to control a disease than it is to replace the plant. Usually an immune cultivar or different type plant should be selected as a replacement because many insects and disease organisms reside in the soil. The best defense against diseases is to keep plants in a healthy condition by applying good maintenance practices during the establishment period and thereafter.

e. Animal damage. Occasionally, animals will chew or gnaw the bark of plants. This weakens the plant's natural defense against diseases and insects. If damage from animals occurs, a commercial pruning paint should be applied to the wound after trimming away any damaged tissue and ragged bark. In localities where Animal damage is likely to occur, protective cages fashioned from wire mesh or window screen may be placed around plants or the base of plants may be painted with a commercial repellent (fig 3-5). Actions to eliminate or relocate problem wildlife species should first be coordinated with local and state wildlife officials.

f. Additional pruning. Plants of good quality should require little additional pruning during the establishment period. Additional pruning usually will be limited to removal of dead or broken branches and some cutting back of shrubs. Pruning should be accomplished by making a clean cut in living wood without bruising tissue or tearing bark and without leaving stubs. Horizontal cuts may heal imperfectly or become rotted and should be avoided. If it is necessary to remove large branches, an initial cut should be made on the bottom of the branch to prevent tearing the bark. All cuts made in branches 1-inch or more in diameter should be painted with a commercial pruning paint.

g. Removal of guy wires, identification tags and tree wrapping. Plants should be inspected periodically to determine if guying and staking devices or identification tags should be loosened. Growth of trunks and branches can cause tight wires to cut into the bark. At the end of

two growing seasons, all guys, stakes and tree wrapping should be removed. Tree wrapping allowed to remain any longer may foster the development of insect infestations on the bark.

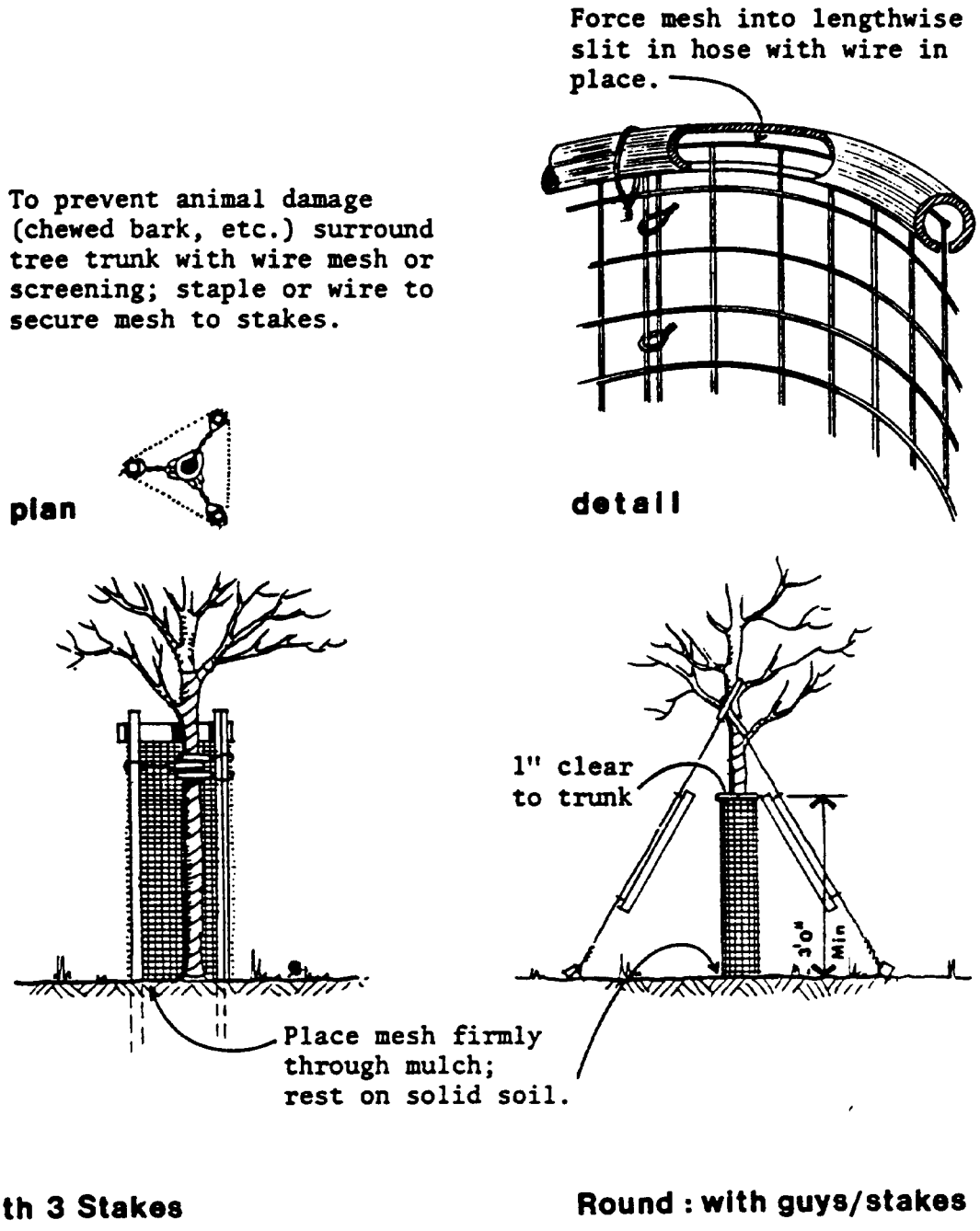


Figure 3-5. Protective cages.

CHAPTER 4
ESTABLISHMENT OF TURF

4-1. General. The most critical factors in the selection and establishment of turf are: evaluation of existing site and climatic conditions; proposed use of the site under consideration; and maintenance requirements. Other information in this chapter is intended to aid in the actual establishment of turf once a selection is made. Included are site preparation, installation and establishment period.

4-2. Microclimatic conditions. Microclimatic conditions relate directly to the site and its environs. They cannot be shown on regional maps because of their site specificity.

a. Sun and wind exposure.

(1) *Sun.* The total amount of solar energy a given turf area receives is determined by the weather, land slope in relation to year-round solar angles and degree of shading by other vegetation and buildings. South-facing slopes will normally have a hot, dry microclimate; north-facing slopes are usually cool and moist because of lower direct solar input and reduced evapotranspirational loss compared with south-facing slopes. In some situations, a different turf variety will be required for each side of the slope. Shade-tolerant cultivars should be considered when sun exposure is limited.

(2) *Wind*. Wind affects turfgrass adaptation in several ways, the most critical of which is as an abrasive force. Turf subjected to high winds may be damaged if it is not resistant to abrasive wear. The use of protective mulch is required for the establishment of turf in areas where high winds prevail.

b. Existing grade and drainage. Excess surface water can adversely affect the quality of turfgrass by reducing its vigor, creating a shallow root system and increasing the potential for compaction and disease if water is not removed by either surface or subsurface drainage. Existing drainage conditions give clues to potential drainage problems and opportunities for improvement. Since surface drainage is related to the grade of a site, sites with natural slopes are usually more easily drained than flat sites. Subsurface drainage will take place naturally if the subsurface soil has suitable permeability and structure.

c. Existing vegetation. Permanent vegetation on a site affects wind movement, humidity, temperature and sun exposure to varying degrees, depending on the density and height of tree crowns and spacing between individual trees and shrubs.

(1) *Density of the tree crown.* Evergreen vegetation has most effect on microclimate conditions since the tree crown is dense and foliage is retained throughout the year. The seasonal loss of foliage by deciduous vegetation provides an opportunity for increased sun exposure and turf growth. Sun exposure may be increased near trees by pruning lower branches to a height of S to 10 feet.

(2) *Spacing between individual trees and shrubs.* Thinning may be desirable in areas with dense vegetation, especially if vegetation is diseased or damaged.

4-3. Proposed use of the site. Careful consideration should be given to the anticipated use of an area before turfgrass selection is made. Depending on the intensity of use and the level of anticipated maintenance, there are three categories of use: improved, semi-improved, and unimproved. The application of these categories is as follows:

a. Improved grounds. Improved grounds include acreage on which intensive maintenance activities must be performed annually. Included are areas within the built-up section of an installation which contain lawns and landscape plants, parade grounds, drill fields, athletic facilities, cemeteries, golf courses (excluding roughs) and similar areas. Maintenance operations include mowing, irrigation, fertilization, cultivation, aeration, seeding, sodding, spraying, pruning, trimming, weed control, insect and disease control, planting for landscape effect, wind and sound abatement and other intensive practices.

b. Semi-improved grounds. Semi-improved grounds include areas on which moderate, periodic maintenance is performed. Included are small-arms ranges, antenna facilities, picnic areas, mowed road shoulders, golf course roughs, ammunition storage areas, firebreaks and similar areas. Maintenance practices normally include such cyclic variables as soil sterilization, weed and brush control, erosion and dust control, drainage maintenance and mowing for fire protection.

c. Unimproved grounds. Unimproved grounds include all other acreage not classified as improved or semi-improved. Included are bombing and gunnery areas; impact, training and maneuver areas; forest areas; agricultural and grazing lands, lakes, ponds and swamps; beaches; and similar areas requiring limited or no maintenance. Maintenance practices are those which might be required by the military mission; soil, water and wildlife conservation; floods and fires; and insect or disease epidemics.

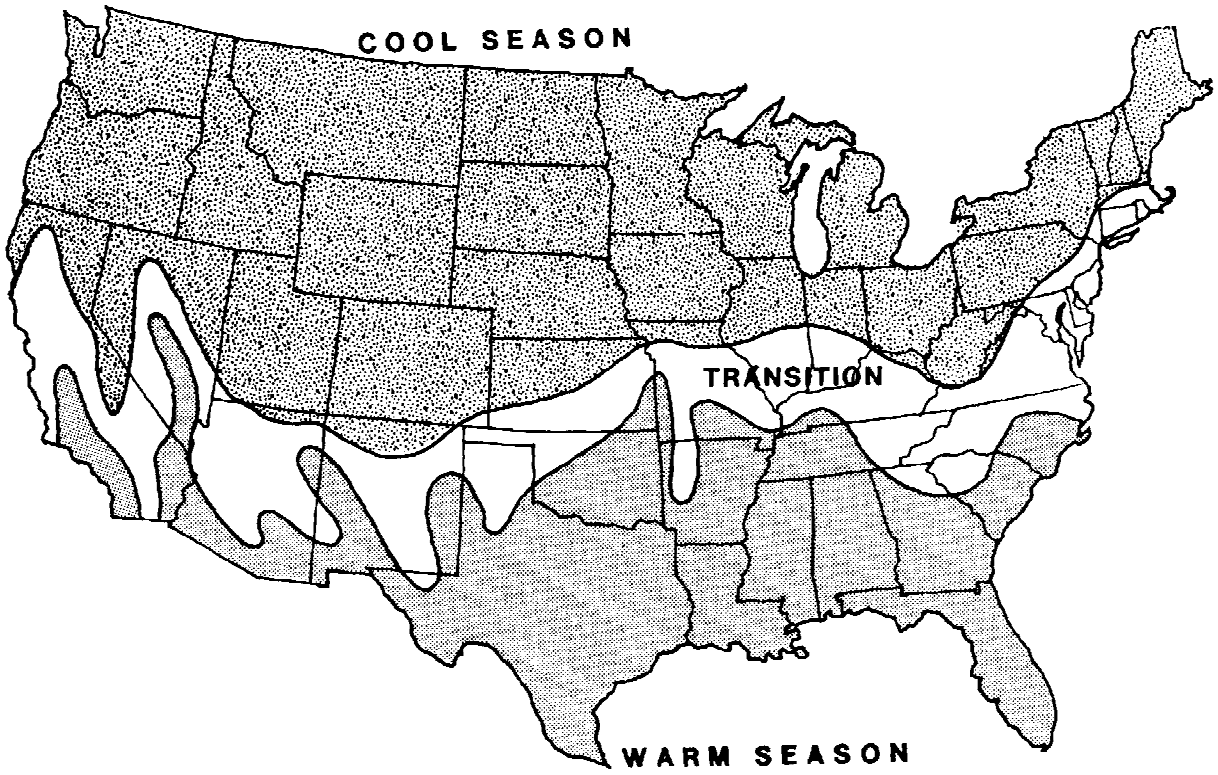
d. Use in relation to existing conditions. The intensity of use and level of maintenance determine both cat-

egories of use and the impact on the immediate environment. Environmental impact will be greatest in improved areas, because the site is altered to provide for intensive use and high maintenance. Unimproved areas have the least impact on the existing environment because very little, if any, site preparation is done and maintenance is minimal. A blending of the two extremes creates a moderate environmental impact, such as in semi-improved areas where site preparation and maintenance are at moderate levels.

4. Selection of turf and turf alternatives.

a. Major regions of turfgrass adaptation. The adaptability of turfgrass species in different regions of the country is based primarily on tolerance of particular temperature conditions and season of most active growth for the cultivar. These regions are illustrated in figure 4-1 as three categories: warm-season, temperate or cool-season and a zone of transition. This is a highly simplified approach to the climatic diversity which exists within the United States. Therefore, it is recommended that local university agronomists, Agricultural Extension Service agents or USDA Soil Conservation Service district representatives be contacted for local guidelines. Warm-season grasses are those which have optimal growth during daytime temperatures of 80 degrees to 95 degrees Fahrenheit, and cool-season grasses prefer temperatures of 60 degrees to 75 degrees Fahrenheit. The transition zone is an area of overlap where some species of both warm and cool-season grasses can exist or adapt. The following paragraphs discuss the major characteristics of warm-season, cool-season and transition zone grasses. Individual species for each zone are discussed in appendix C.

(1) *Warm-season grasses.* These grasses grow most actively during the hot summer months and become inactive during the winter. During this winter dormancy



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Figure 4-1. Major regions of turfgrass adaptation in the United States.

period, the grasses turn brown. Overseeding with cool-season grasses will provide winter color and protection for year-round use. Most warm-season grasses are propagated by vegetative methods such as sprigging or stolonizing rather than by seeding. Major species of warm-season grasses are Bahiagrass, centipedegrass, Bermuda grass, St. Augustine and zoysia.

(2) *Cool-season grasses.* These grasses grow most vigorously during the spring and fall when temperatures are cool and experience a dormancy period during hot summer months. They retain their color throughout the winter and are usually propagated by seed, rather than vegetatively. Major cool-season grasses are bentgrass, Canada bluegrass, Kentucky bluegrass, chewings and red fescue, tall fescue and perennial ryegrass.

(3) *Transition zone grasses.* Because the transition zone is an area of overlap between warm and cool season grasses, the boundary shown in figure 4-1 should be used only as a guideline. Warm-season grasses, in order to be adaptive in this area, must display tolerance to cool conditions. Cool-season grasses, on the other hand, must be tolerant to heat and drought. In most cases, a given species as a whole will not display these qualities, though individual cultivars may. Bentgrass, Bermuda grass, Kentucky bluegrass, tall fescue and zoysia may be successfully grown in the transition zone.

b. Seed mixtures and blends. A more satisfactory stand of turf can often be provided by selecting a blend or mixture of species or cultivars than by use of any single variety. Selection of compatible turfgrass is based on similar texture, color and maintenance requirements. It is advisable to include grasses in the seed mixture which will increase disease tolerance, adapt well to moisture or temperature extremes, increase the range of tolerance to sun and shade, and improve the rate of establishment. Propagation of mixed grasses should be by seed only. For this reason, mixtures of warm-season grasses, most of which must be propagated vegetatively, are generally not considered practical. Usually only one or two grasses can be expected to persist longer than 5 years in a mixed turf. Grasses which do not contribute to a long-lasting turf should not be included in the blend except for use as nurse grass to provide quick cover for erosion control.

(1) *Common seed mixtures.* One of the most commonly used mixtures is Kentucky bluegrass (Poa pratensis) and chewings fescue (Festuca rubra). They are usually represented in equal proportions (50-50) except in areas with sandy, droughty soils or in deep shade. In these areas a higher percentage of chewings fescue is included (30-70). In the Pacific Northwest, an appropriate mixture for recreational areas is equal proportions (50-50) of Kentucky bluegrass and perennial ryegrass (Lolium perenne). In areas of the arid West, mixtures of native grasses are most appropriate. Blue grama (Bouteloua gracilis) and buffalograss (Buchbe dactyloides) are appropriate grasses for silt and clay loams in unimproved areas (75-25). In sands and sandy loams, the percentage of buffalograss should be replaced with sand dropseed (Sporobolus cryptandrus).

(2) *Nurse grasses.* Frequently, a mixture will contain a percentage of nurse grass. Nurse grasses are fast-germinating, temporary grasses which emerge prior to other grass species. They favorably alter the microclimate conditions of the site for other species and provide erosion control where applied mulches are impractical. Because of their competitive nature, nurse grasses should comprise less than 20 percent of the total mixture and should not be used in areas of low rainfall. Annual ryegrass (Lolium multifiorum) and redtop (Agrostic alba) are appropriate for use as nurse grasses.

(3) *Winter overseeding.* The practice of seeding cool- season grasses into an established stand of grass during the fall is known as winter overseeding. This practice is common in warmer regions of the country where Bermudagrass and other grasses become dormant in the winter. The practice of overseeding is not compatible with all dormant winter grasses, especially the dense-growing types such as St. Augustine, zoysia and centipedegrass. Winter overseeding provides the winter color, uniformity and active root growth required for year-round use. When warm temperature resume in the spring, the cool-season species die hack and the warm-season species again dominate.

(a) Improved or semi-improved areas. A single species or a mixture of species may be used for over- seeding to provide the desired qualities. Appropriate single species are rough bluegrass (Poa trivialis), red fescue (Festuca rubra) and annual ryegrass (Lolium multifiorum). Appropriate mixtures are tall fescue (Festuca arundinacea), red fescue and perennial ryegrass (Lolium perenne); bentgrass (Agrostis spp.), rough bluegrass and red fescue; Kentucky bluegrass (Poa pratensis), rough bluegrass and red fescue; and Kentucky bluegrass, tall fescue and perennial ryegrass.

(b) Unimproved areas. Either burclover (Medicago hispida) or crimson clover (Trifolium incarnatum) may be used for overseeding in unimproved areas.

(c) Alternatives to *turf.* In areas with poor site conditions, it is advisable to consider treatments other than turfgrass. The use of turfgrass alternatives generally reduce maintenance requirements.

(4) *Miscellaneous grasses.* Miscellaneous grasses which do not qualify as turfgrasses may be appropriately used in some situations. These grasses are often more tolerant to harsh conditions and can be more easily established, especially in areas of the arid West. Further information on local adaptation should be obtained from county Agricultural Extension Service agents, university

agronomists or USDA Soil Conservation Service district representatives.

(5) *Legumes and ground covers*. These plants, often of ornamental value, can be used where turf establishment or maintenance is difficult and where little or no foot traffic exists. Properly established and maintained ground covers will require less maintenance than turf-grass; however, initial maintenance (during the first one to three years) will be high. Many legumes and ground covers can be recommended as turfgrass alternatives; however, availability and climatic adaptation will determine final selection.

(6) *Wildflower mixes*. The seeds of mixed species of wildflowers may be substituted for all or part of the grass seed in a seed mixture. Wildflower plantings are appropriate for large flat areas or slopes in areas with little or no foot traffic. These plantings are limited to semi-improved and unimproved areas. Care should be taken to select self-sustaining species which are locally hardy and thrive without regular care or irrigation. Species should not be selected which produce large numbers of wind-borne seeds that may spread to other areas of the installation.

(7) *Artificial turf*. The use of artificial turf is generally not recommended due to cost and maintenance requirements.

(8) *Porous surfaces*. Porous surfaces of crushed rock or gravel aggregate may be used in areas where grasses cannot survive due to drought or poor soil conditions. In areas where irrigation is impractical, rainfall is low or soils are unproductive, a 1 to 2 inch blanket of gravel or crushed rock may be used. Crushed rock should be coarse enough to allow drainage.

4-5. Site Preparation.

a. Clearing and grading. The extent of clearing and grading in an area where turf is to be established will be governed by site use, land slope, climatic conditions and planting method. Clearing and grading should be minimized to avoid unnecessary dust and erosion. Prior to grading, reusable topsoil should be removed and stockpiled.

(1) All turf areas should be graded to have slopes not steeper than 3:1; 4:1 slopes are optimum. If slopes are too steep, mowing with standard equipment can be hazardous. Athletic areas should be graded with a 1.5 to 3 percent slope toward the sidelines, and lawn areas with a 1.5 percent slope away from buildings. In areas with pavement, turf grades should be established 1 inch below pavement grades. Abrupt or irregular grading makes maintenance more difficult and should be avoided. Swales should be preserved or installed during grading to receive and convey surface drainage. Vegetation should be preserved in swales where erosion potential is high.

(2) The final grading of a site will determine its potential for surface drainage. In extreme cases, such as sites with heavy clay soils, implementation of subsurface drainage may be necessary to remove excess water. When natural drainage is poor enough to warrant subsurface drain lines, alternatives to turf should be sought so that costs and maintenance problems can be minimized. TM 5-820-4/AFM 88-5, Chap 4 contains guidance for drainage in areas other than airfields.

b. Soil modification. The incorporation of amendments in an existing soil can improve soil texture and structure so that a high-quality turf can be established. Soil modification is especially appropriate in semi-improved and improved areas where the existing soil has a high clay or sand content. Soil amendments should be worked into the soil to a depth of 8 to 12 inches. In many cases, an adequate vegetative cover can be established without amending the existing soil. Where soil texture is expected to present a management problem, a mechanical analysis of the existing soil should be obtained and prospective sources of available soil amendments determined.

(1) *Sand.* The incorporation of large sand particles into clay soils will enhance aeration and water percolation, as well as reduce the tendency for compaction. It is necessary to incorporate at least 2 inches of coarse sand into the upper 6 to 8 inches of the existing soil to create adequate pore space. Use of ungraded sand with a high percentage of fine particles may intensify the problem rather than alleviate it.

(2) *Organic amendments.* The addition of organic matter improves soil structure and aeration and promotes nutrient and water retention. Sandy soils especially benefit from the addition of organic matter. The amount of organic material added to a soil may vary; however, recommended amounts for 1,000 square feet of soil are 3 to 4 cubic yards of well-rotted compost, 2 to 3 cubic yards of rotten manure or 3 bales of peat moss. Other materials which may be used are rotted sawdust or ground bark. Nitrogen deficiencies can occur if organic materials are not decomposed when they are added to soil.

(3) *Topsoil.* Topsoil is a select or mixed soil material applied to a soil surface prior to seeding or planting turf. Grading and provisions for surface drainage should be completed prior to the addition of topsoil. Replacement of existing topsoil is generally unnecessary except where there are disproportionate amounts of sand, silt or clay. In such eases, a gradual transition of soil material is necessary in order to provide good internal drainage.

c. Nutrient additives. Soil fertility can be adjusted by the addition of nutrients as determined necessary through soil testing.

(1) *Gypsum*. Gypsum is used to improve soils which have a high percentage of soluble salts. Where pH

is at the right level but the soil needs conditioning, especially if it is heavy clay, gypsum should be used. It has little effect on pH.

(2) *Lime.* Lime acts as an agent to increase the availability of nitrogen, phosphorus and potassium and other chemicals. Lime is commonly used in acid soils to raise pH to a less acid level. Common liming materials are ground limestone, hydrated lime, burned lime and marl. Lime should be applied at a rate and frequency determined by the combination of a laboratory soil test and the recommendation of a local turfgrass specialist. In areas where lime is required, it should be added two or three months prior to fertilization and mixed in the soil to a depth of 6 inches. The best season for application is late fall or early winter.

(3) *Sulfur.* The addition of sulfur lowers pH values and causes soil to become more acidic. Sulfur is very rarely added except in areas where soils are extremely alkaline.

(4) *Fertilizers.* A complete fertilizer is commonly used for turfgrass establishment, unless a soil test indicates otherwise. Fertilizers should be applied to the finished seedbed. Nitrogen fertilizers are divided into organic and inorganic types. Organic types release nitrogen slowly, providing for uniform stimulation over a long period of time and usually cost more per unit of actual nitrogen. Processed sewage sludge is an example of an organic nitrogen source. Inorganic fertilizers are water soluble and are available as dry materials which require thorough watering into the soil. Inorganic fertilizers must be applied in smaller quantities than organic types. The following are inorganic nitrogen fertilizers:

— Ammonium nitrate.
— Ammonium sulfate.
— Ammonium phosphate.
— Calcium nitrate.
— Nitrate of soda.
— Urea.

d. Tillage. Tillage may be desirable for one or more of the following reasons: loosening compacted soil, reducing soil erosion, destroying weeds or adding fertilizers and lime. Deep tillage may also improve soil drainage and promote the establishment of a deep root system.

(1) *Initial tillage.* An ideal seedbed is made by tilling the graded soil surface to a depth of 6 to 8 inches to eliminate areas that may be packed and bard. The tilling process also brings objectionable materials such as stones, stumps, large roots and building refuse to the surface, where they can be more easily removed. A disk harrow can be used to loosen the soil surface except in areas where heavy machinery has packed the soil. A disk plow or chisel-type tillage tool may be required on heavily compacted soils.

(2) *Pulverizing the surface.* The soil surface should be harrowed and raked level following tillage to prevent the formation of depressions. A fine-textured seedbed is important for initial seedling growth. Where large clods are present, a cultivator packer should be used instead of a harrow to pulverize clods.

(3) *Timing.* Seedbed preparation should take advantage of favorable soil moisture conditions. Soils should not be cultivated when wet, although compacted soils should be softened by rain or irrigation prior to tillage.

(4) *Grade elevations.* The soil surface should be true and even and grade elevations undisturbed to ensure that surface drainage is directed away from buildings and pavements and that there are no depressions where water will stand. The grade should be rechecked after the seedbed has been prepared. The final grade must be approximately 1 inch below adjacent sidewalk and runway elevations on lawns and airfields to prevent water from accumulating on the pavement and to permit efficient turf maintenance.

(5) *Correcting the grade.* The seedbed may settle considerably after a heavy rain or irrigation. Such settlement is seldom uniform but tends to occur in spots, leading to expensive replanting later. This is especially objectionable on lawns and recreational areas where a true final grade is essential. The soil surface should be checked for depressions and fill added to bring the grade to the correct elevation.

e. Protection of adjacent areas. Every precaution should be taken to avoid the disturbance of existing vegetation adjacent to the site. Major grading and the use of heavy equipment should be restricted to the outer drip lines of existing trees. Temporary fencing may also be advisable.

f. Erosion/Nonpoint source pollution control during site preparation. The implementation of best management practices (BMPs) can minimize and control erosion during preparation. Disturbed areas should be limited and soil surfaces should be left rough to enhance water infiltration. Stabilization and planting should be implemented as soon as possible after a site is disturbed. If a delay in planting is encountered, temporary mulching may be necessary. Soil erosion may be minimized by applying the following BMPs when applicable.

(1) The area of land that is exposed to erosion at any one time during construction should be limited.

(2) Temporary mulch should be applied on cleared areas of the construction site immediately after rough grading is completed.

(3) Sediment basins may be constructed to precipitate silt from storm runoff before it leaves the site.

(4) Temporary grade stabilization devices such as silt fences, diversion berms, water spreaders, sodded channels and asphalt flumes may be constructed.

(5) Permanent storm drainage systems and base course for all pavements should be installed at the earliest practical time.

(6) Final stabilization should be accomplished immediately after finish grading is completed. Mulch should be applied regardless of season, and seeding, sodding or sprigging delayed if necessary, until the season is most favorable for establishment of grass or ground cover.

g. Chemical soil treatment. When large numbers of noxious weeds or weed seeds are present, it may be necessary to chemically treat the soil before planting turf. Alternative treatments include pre-emergent herbicides, contact herbicides and soil fumigants. TM 5-629/NAVFAC MO 314/ AFM 91-19 contains guidance for use of these chemicals.

4-6. Planting operations.

a. Seed quality. Grass seed, as sold commercially, normally contains many impurities. Seed quality is dependent on the percentage of pure live seed contained in a particular species. Federal seed laws require that the containers of seed offered in interstate trade exhibit the percent germination and percent purity. The label will normally show each weed seed which is considered noxious by the state in which the test is made. Canada thistle, field bindweed, dodder, buckthorn, wild onion, quack grass and Johnson grass are common examples. Appendix C contains further information relating to seed quality.

b. Seasons most favorable for planting. The most favorable time for planting turfgrass is just before a 6 to 8 week period of optimum soil temperature and moisture. Although germination requirements vary according to species, seasonal preferences exist among grasses adapted to the same region.

(1) *Warm-season grasses.* The optimum time for establishment of warm-season grasses is late spring or early summer. Late summer or fall plantings are seldom successful and should be avoided.

(2) *Cool-season* grasses. Cool-season grasses should be planted in early fall or early spring. The chances of poor establishment increases with the approach of hot weather.

(3) *Transition-zone* grasses. Follow guidance as in (1) and (2) above.

c. Planting methods.

(1) *Seeding.* Mechanical seeding is the most common and least expensive method of planting turfgrass. Good results are dependent on uniform seed distribution, adequate soil cover over seeds and firm soil around the seed. Grass seed drills are the least desirable method for seeding turfgrass, because seeds are not distributed uniformly but in rows 6 to 8 inches apart. Seed drills will, however, reduce the seeding rate and may be appropriate on large or unimproved areas. Some seed drills may plant seeds too deeply. Broadcast seeders are the fastest method of seeding; however, a method for covering and firming the soil must follow, such as the use of a cultipacker. A broadcast seeder will not provide uniform distribution of seed mixes which contain seeds of different sizes and weights. Hydroseeding is appropriate for use in large areas. Seed is mixed with fertilizer, mulch and water, made into a slurry and applied in a one-step process. The greatest disadvantage of hydroseeding is that the seed is placed on the soil surface where it is more susceptible to the effects of drought.

(2) *Sprigging.* Sprigging involves the planting of turf stolons or rhizomes in shallow furrows 1 to 2 inches deep. Rows are usually 18 inches apart with sprigs placed 6 to 12 inches apart in the rows. In areas where rapid establishment is not crucial, rows may be up to 3 feet apart. Sprigs should be kept moist and planted immediately after digging. Plant shipments should be coordinated with the planting schedule to allow immediate planting.

(3) *Sodding.* Sodding is the most expensive method of planting turfgrass. The use of sod should be limited to areas where quick turf establishment is required to repair previously planted areas. For irrigated sites, uniform sod with a thickness ¾ to 1 inch is recommended. Sod should be free of objectionable grasses and noxious weeds. Sod installations on slopes require pegging to prevent significant slippage.

d. Mulching.

(1) *Applied mulches.* Surface erosion and damage from drying winds can be effectively controlled under most conditions by applying vegetative or manufactured mulches. On most planting sites, mulching offers substantial benefits by providing protection from wind and rain. Mulches influence conditions in the surface layers of the soil and thus aid in seed germination and establishment. Seasonal fluctuations in soil temperature are kept at a moderate level and water absorption is increased. Mulching is also helpful in weed control. Effective mulches include cereal straw, shredded bark and leaf mold. Hydraulic applications of wood cellulose fiber and/or recycled paper will provide considerable protection if applied at a sufficiently high rate. Woven net mulches, such as woven paper or jute, are not consistent in effectiveness. Sawdust and glass fiber are seldom acceptable. Mulch can be applied manually or mechanically.

(2) *Planted mulches.* Under some conditions, applied mulches are not practical. Some areas are so isolated that the purchase and shipment of mulch material are not cost-effective. In other areas, the planting of temporary cover crops may be the most economical method if time and site conditions permit. In situations where rainfall is abundant and the soil surface does not

erode severely, a permanent grass may be planted simultaneously with a nurse grass.

4-7. Establishment. The length of time necessary for turf to become established varies according to species, method of planting and site conditions. In most cases a reasonable establishment period is 3 months or until the turf has been mowed three times.

a. Watering. Maintenance of a moist soil surface is critical during the establishment period, especially where a durable, long-lasting turf is required. Immediately after planting, the soil should be thoroughly moistened. Light daily watering may be necessary for 2 to 3 weeks. Heavy applications of water which results in puddling and runoff will disrupt establishment and promote disease. The use of a mulch reduces the need for frequent watering.

b. Mowing. Mowing should begin when turf reaches a height one-third greater than the anticipated cutting height. Mowing should continue at the height and frequency required of the established turf. The initial mowing of areas established by sprigs should begin when sprigs reach a height of 3 to 4 inches, except for zoysia, which establishes best at a 1 inch height, Mowing should be done with sharp equipment on dry, firm soil.

c. Topdressing. Topdressing is applied to stoloniferous species to increase the formation of dense sod. A light covering with a material similar to the underlying soil is recommended. Top dressing should be applied at intervals of two to three weeks during the initial establishment period.

d. Fertilization. Under some conditions, application of fertilizer prior to planting may not be sufficient to maintain active plant growth during the establishment period. The need for a higher nitrogen level can be detected by stunted growth and a yellowish leaf color, especially where adequate moisture has been supplied. Seeded areas should not be fertilized until seedlings reach a height of 1 to 1½ inches. Sodded areas do not require fertilizer during the establishment period.

e. Weed control. Herbicides may injure the root system of new plantings and are usually unnecessary until after the establishment period. Weed control should not be necessary in sodded areas.

f. Traffic control. Seeded areas are especially susceptible to damage until turf is mature, and should he protected by barriers.

g. Repair of planting failures. Unexpected environmental conditions, such as lack of rainfall and unfavorable temperatures, can cause planting failures. Regardless of whether the failures are in large or small areas, repair should he prompt in order to take advantage of the planting season. If the planting season has expired, mulching will be necessary to protect the site until the next planting season. Low spots should be promptly filled and replanted. Areas where seeds have failed to germinate should be repaired by reseeding.

APPENDIX A
REFERENCES

Government Publications

Departments of the Army, Navy and the Air Force:

AFR 700-20, Vol.3	Data Elements and Codes (Classified)
AR 415-28	Facility Classes and Construction Categories
TM 5-629/NAVFAC MO-314/AFM 91-19	Herbicide Manual for Non-Cropland Weeds
TM 5-630/NAVFAC MO 100.1/AFM 126-2	Natural Resource Land Management
TM 5-803-5/NAVFAC P-960/AFM 88-43	Installation Design
TM 5-820-4/AFM 88-5 Chap 4	Drainage for Areas Other Than Airfields
TM 5-830-3/AFM 88-17 Chap 3	Dust Control

Nongovernment Publications:

American Association of Nurserymen, 230 Southern Building, Washington, D.C. 20005

American Standard for Nursery Stock (ANSI Z60.1-1980)

APPENDIX B
STREET PLANTINGS

B-1. Introduction. The use of street plantings, particularly trees, is one of the most effective means to enhance and define the road hierarchy. Trees will also provide shade and improve the overall visual quality of the installation. A systematic design approach should be employed to establish a coordinated street planting program for the entire installation.

B-2. Relationship to master planning. If the visual quality of military installations is to be improved, design procedures and guidelines must be incorporated into the master planning process. It is at the master planning level that there is an appropriate overview directed at insuring overall compatibility of individual program needs. Formulation of an installation street planting program to support the overall objectives of the installation master plan will provide guidelines for improving the visual quality of a military installation.

B-3. Assessment of the existing environment. The steps listed below should be followed in assessing the existing situation. TM 5-803-5/NAVFAC P-960/AFM 88-43 explains each of these procedures in detail.

— Overview visual survey.
— Supplementary visual surveys.
— Documentation of findings.

B-4. Formulation of design guidelines.

a. Goals and objectives. In order to develop an installation street planting program, it is necessary to establish specific goals and objectives. The specific mission, priorities, existing visual assets and liabilities, and planned changes for each installation should influence the formulation of these goals and objectives.

b. Overall design criteria and guidelines. After design objectives for the installation have been established, design criteria responsive to these objectives should be formulated. Based on these criteria, overall design guidelines for the installation should be established. Some general criteria and guidelines for street plantings are as follows:

(1) Street trees should be placed between the sidewalk and the building, leaving the strip between the sidewalk and the curb free for underground utilities and traffic and street lights. If there are no sidewalks, the distance between the curb and the trees should be at least four feet to prevent damage to trees from vehicles.

(2) In the design of a street planting, separate plant species may be used to identify distinctive details or areas of the installation, for example, a particular land-use relationship, historic district, community area or other similar entity.

(3) The selection of tree species, spacing and location along roads should bear a relationship to the class of roadway. Roadways are generally classified as arterial, secondary or collector, or local. Plantings should reflect the nature and speed of passing traffic. The visual and psychological impact of tree plantings is of very real value in establishing a hierarchy of traffic flow from installation entrances to major and minor roads. A clearly structured and consistent planting scheme can provide overall visual coherence on the installation.

(4) A palette of readily-available, hardy trees with suitable growth characteristics should be developed for use as street trees. These should include large, medium-sized and smaller trees and may include flowering species. A variety of disease and insect resistant species should be used to insure that an infestation of insects or disease does not decimate the street tree plantings on the entire installation.

(5) Initial size of large growing trees should generally be about 2½ inch caliper. This size tree is usually available in sufficient quantity, recovers well from transplanting and grows rapidly once established. Smaller-growing trees can be proportionately smaller initially. However, small flowering trees should be at least 8 to 10 feet high with trunks of 1 to 1½ inch caliper.

(6) The selection, location and spacing of street trees must accommodate the safety requirement of vehicles and pedestrians. Adequate sight distances must be maintained at intersections, driveways, cross-walks or other locations where clear vision is important. Criteria for safety must include an analysis of road size and alignment and speed and volume of traffic.

B-5. Alternatives to linear tree plantings. Linear arrangements are traditional for street tree plantings because they are simple, economical and dramatic. However, in some areas, a less formal planting may be more successful. In more developed parts of the installation, planting spaces may be limited or irregular in shape because of underground utilities. In this case, irregular, nonlinear plantings may provide flexibility to fully utilize those spaces that provide the best growing conditions. Trees should only be planted where there is adequate soil and space (fig B-I). Nonlinear planting designs may incorporate cluster plantings when sufficient space is available. These clusters may include tall, canopied species, smaller under-story plants and ground covers (fig

B-2) Nonlinear plantings may also provide a better match of plant species to varying microclimate, soil or traffic conditions. Opposite sides of a street may have dramatically different microclimates or varying parking or pedestrian patterns (fig B-3).

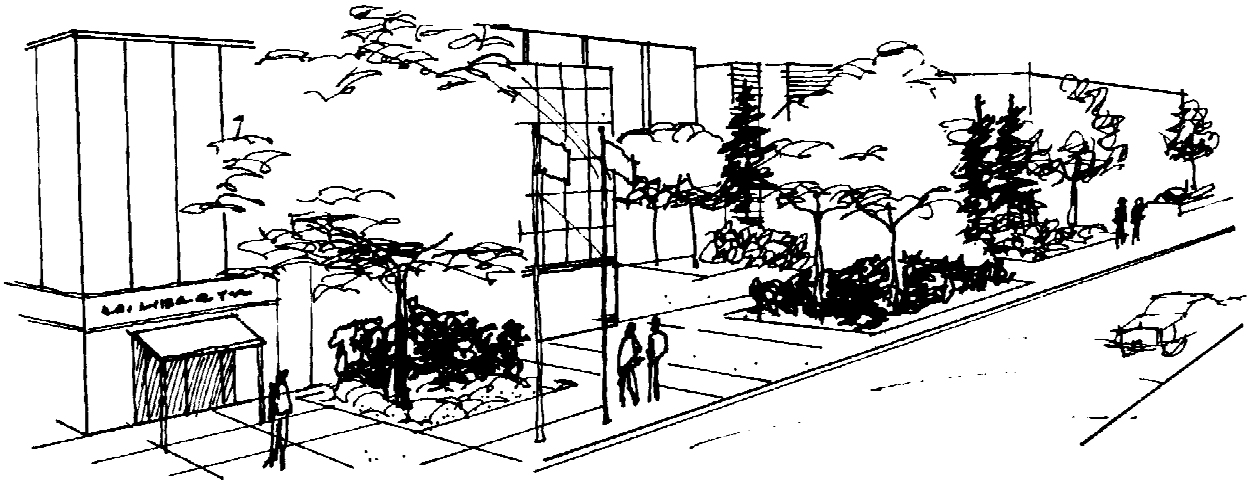


Figure B-1. Nonlinear street plantings.



Figure B-2. Cluster plantings.

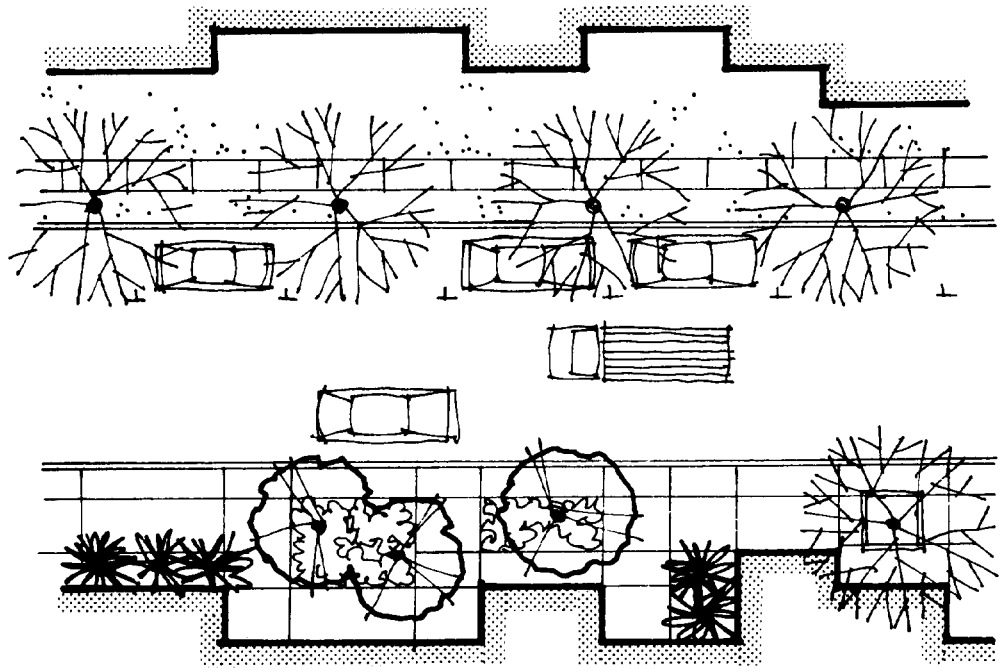


Figure B-3. Varying conditions.

B-6. Site preparation for street plantings. With proper planning, trees can thrive in developed areas in spite of air pollution, temperature extremes and high winds. To survive under these conditions, tree roots must have a suitable environment. It is often difficult to supply adequate oxygen, water and nutrients in individual planting pits in paved areas. Cluster planting can provide an area large enough for groups of plants to protect each other by creating a mutually beneficial microclimate, where plants partially shade and cool each other and the soil.

a. In most cases, soil from the site should not be replaced because tree roots must eventually grow into the surrounding soil. Many times imported soil creates more problems than it solves. If soil is replaced, existing and imported soils should be thoroughly mixed over as large an area as is practical.

b. When it is not practical to plant at grade, the use of raised planting beds should be considered. This practice improves drainage and can be used to direct pedestrian movement without danger of compacting the soil. Raised planters should be at least 8-inches high and bounded by a curb of wood, masonry or cement.

APPENDIX C
SUPPLEMENTAL TURF INFORMATION

C-1. Major warm-season grasses.

a. Bahiagrass (Paspalum notatum). Bahiagrass is an excellent choice for roadsides and other unimproved areas in the warm, coastal areas of the South. Its extensive root system provides an excellent means of erosion control as well as resistance to drought. It is fairly tolerant to salt injury and thrives in infertile, deep, sandy soil. Under low management it is difficult to mow because of numerous seed heads which form a tall, open turf. Bahiagrass is propagated by seed. Establishment rate is usually slow, although some cultivars establish more quickly.

b. Bermudagrass (Cynodon dactylon). Bermudagrass is very adaptable in areas with full sun. In the southern regions, it has a prominence similar to that of Kentucky bluegrass in the northern regions. Bermudagrass is vigorous, withstands heavy use and is resistant to disease and saline soils. It responds well to good cultural practices and must be restrained at its borders. It may be established by seed, sprigs or sod. Some popular Bermudagrass cultivars are excellent for heavy-use, high-maintenance areas such as golf greens, fairways and ballfields. These cultivars must be propagated vegetatively by sprigging or sodding. Common Bermudagrass may be seeded. The species has a coarser texture and is less winter-hardy than its cultivars. Common Bermudagrass is widely used for unimproved areas and may be used for semi-improved areas depending upon the quality of turf desired. Its bronzy seed spikes can be controlled by regular mowing.

c. Centipedegrass (Eremochloa ophiuroides). Centipedegrass is slow-growing, short, dense grass which establishes readily and requires little care. It does best in sandy soils in full sun or semishade in the warm coastal regions of the South. It is not tolerant to saline conditions.

d. St. Augustine (Stenotaphrum secundatum). St. Augustine is a coarse-textured grass useful for lawn areas in the South. It is the most shade-tolerant of the warm-season grasses and it is also tolerant to saline conditions. Although the species is relatively inexpensive to establish, it has high maintenance requirements. St. Augustine requires frequent watering and fertilization. St. Augustine is more subject to insect and disease damage than Bermudagrass; however, some cultivars offer more disease resistance.

e. Zoysia (Zoysia spp.). Zoysia is adapted to areas throughout the southeastern United States for use on lawns and golf courses. Its tolerance to salt makes it well adapted to coastal areas. It is a wear-tolerant species; however, once damaged it is slow to recover. Zoysia is very slow to establish and cover an area. Although close and frequent mowing is necessary, other maintenance requirements are low. Figure C-1 illustrates regional adaptation of warm-season grasses.

C-2. Major cool-season grasses.

a. Bentgrass (Agrostis spp.). Bentgrass is a very fine, elegant grass especially suited to the northern half of the United States. It is used extensively for recreational areas such as golf courses; however, it demands frequent maintenance. It is tolerant to acid soil conditions and prefers full sun. Because of its maintenance demands, it is not desirable for general use.

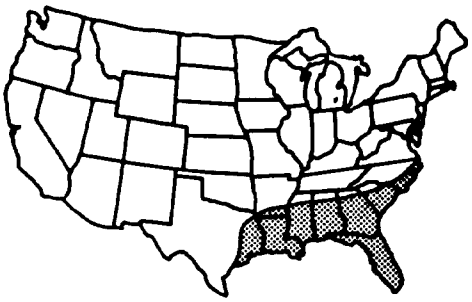
b. Canada bluegrass (Poa compressa). Canada bluegrass is primarily valued for its ability to control erosion on sites with sterile soils. It adapts to the vigorous climate of the Great Lakes region and can be used in shade.

c. Kentucky bluegrass (Poa pratensis). Kentucky bluegrass is an excellent lawn grass for areas in the northern United States. It is the most widely used of the cool-season grasses because it is adaptive to a wide range of soil and climate conditions. Kentucky bluegrass sod is very tough and may be used in semi-improved and unimproved areas such as physical training areas, airfields, parks, cemeteries and open lawn areas. It is very sensitive to close cutting (less than 1½ inches) and it is subject to summer dormancy during stressful periods of high heat and drought. It can be propagated by seed or vegetatively.

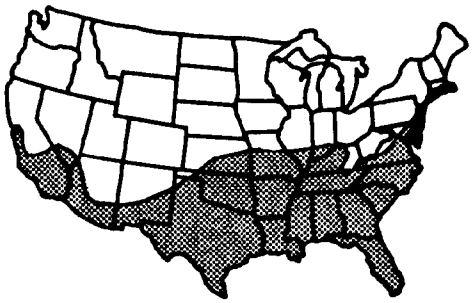
d. Chewings and red fescue (Festuca rubra). These fine textured grasses are well adapted to dry, shady areas in the Northeast and Northwest regions of the United States. They are generally low-maintenance grasses; however, fertilizing is necessary where tree roots and turf compete for nutrients. They mix well in equal proportions with Kentucky bluegrass to provide a dense, continuous turf for lawns.

e. Tall fescue (Festuca arundinacea). Tall fescue is a coarse-textured, unattractive grass, usually not desired for use as a lawn. The grass is very resistant to heavy use, high temperatures and drought. It roots deeply and provides good erosion control in sandy soils.

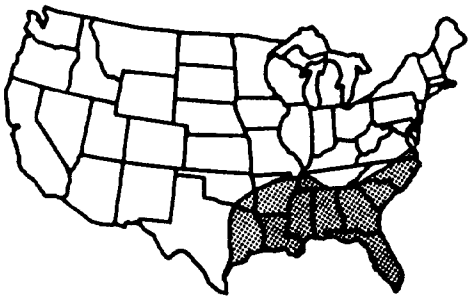
f. Perennial ryegrass (Lolium perenne). Perennial ryegrass is best suited to mild, maritime climates. It produces a coarse, tough turf which is not usually desired for lawn purpose. It germinates and establishes itself



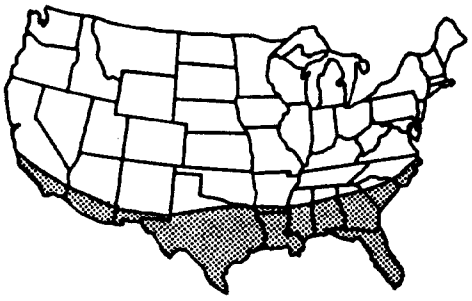
Bahiagrass



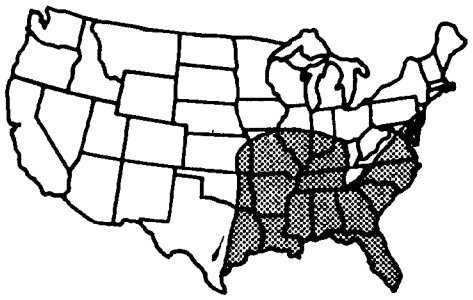
Bermudagrass



Centipedgrass



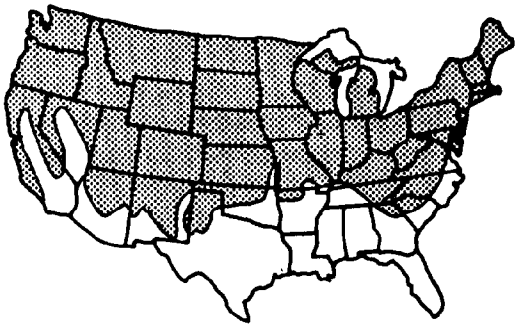
St. Augustinegrass



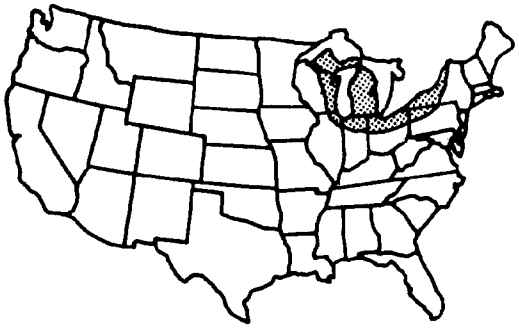
Zoysia

Figure C-1. Regional adaptation of warm-season grasses.

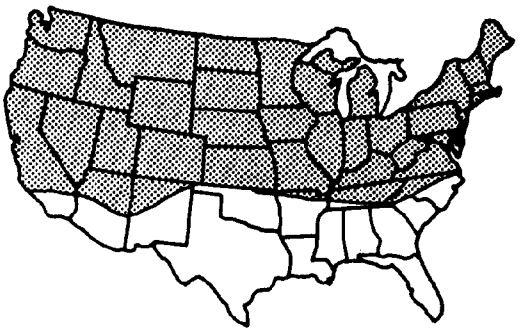
itself quickly and requires fairly frequent mowing. It is not advocated for general use, although it may be useful in shady areas where other grasses cannot survive. There are many fine-leaved ryegrass cultivars, making it a very popular grass. Figure C-2 illustrates regional adaptation of cool-season grasses.



Bentgrass



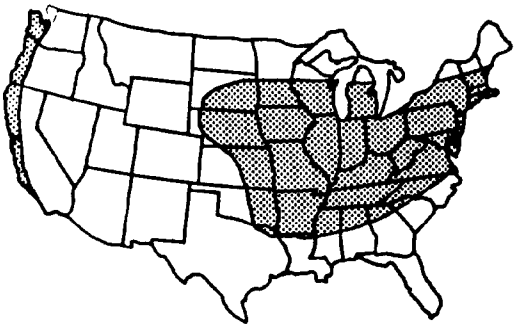
Canada Bluegrass



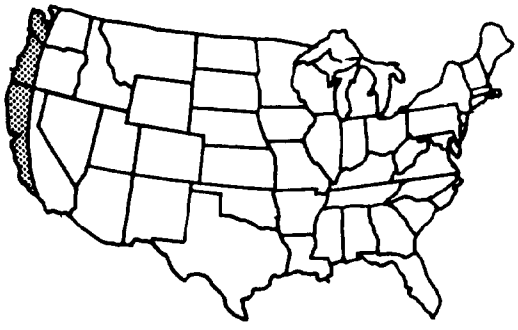
Kentucky Bluegrass



Chewings & Red Fescue



Tall Fescue



Perennial Ryegrass

Figure C-2. Regional adaptation of cool-season grasses.

C-3. Major transition-zone grasses.

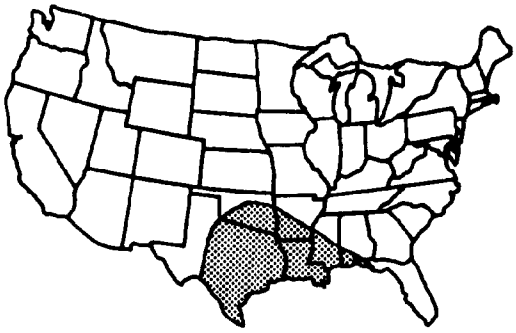
a. Bentgrass (Agrostis spp.). Used primarily for golf and putting greens, bentgrass has high maintenance requirements and is not recommended for general use in the transition zone.

b. Bermudagrass (Cynodon dactylon). Bermudagrass may be used as a transition-zone species depending on the cold hardiness of the individual cultivar selected. Most of these cultivars must be propagated vegetatively. Bermudagrass is primarily used for improved or semi-improved areas.

c. Kentucky bluegrass (Poa partensis). One of the most widely used grasses in the transition zone, Kentucky bluegrass is popular for lawns and general-purpose areas. It is adaptive to sun or open shade; however, in the southern portions of the transition zone, it prefers cooler, shady areas. Kentucky bluegrass is rather susceptible to disease and in warm, humid regions this susceptibility is increased.

d. Tall fescue (Festuca arundinacea). Tall fescue is very adaptive to the transition zone. It is used as a general-purpose turf. In mixtures with Kentucky bluegrass, it should comprise at least 80 percent of the mixture.

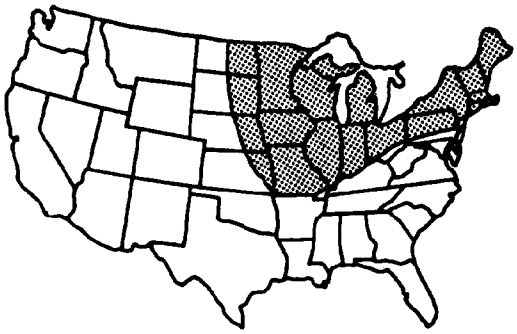
e. Zoysia (Zoysia spp.). Zoysia is primarily limited to the southern portion of the transition zone. Within these areas, it should be used only in areas with full sun. Meyer zoysia is the most winter hardy species of Zoysia and is, therefore, the most appropriate selection for use in the transition zone. Figures C-3 and C-4 illustrate regional adaptation of turfgrass alternatives.



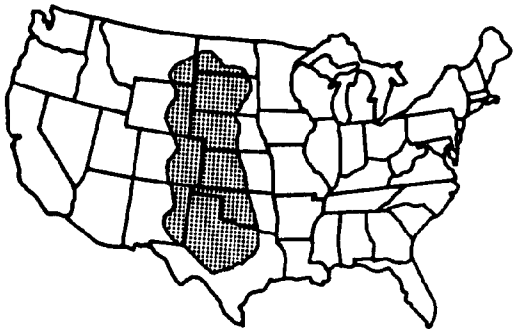
King Ranch Bluestem



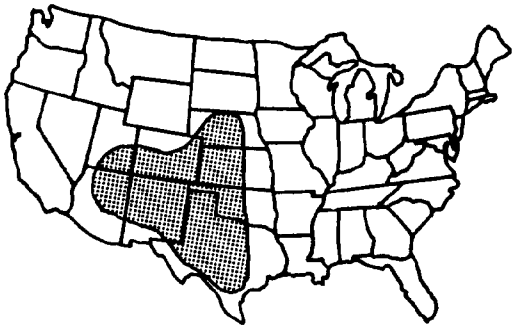
Little Bluestem



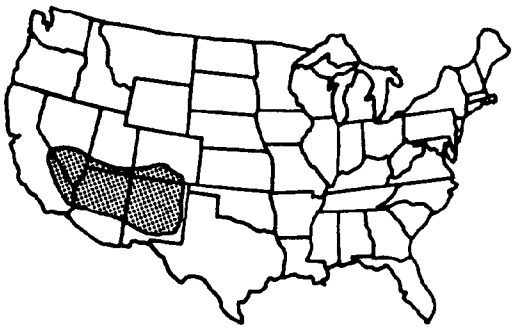
Smooth Bromegrass



Buffalograss



Sand Dropseed

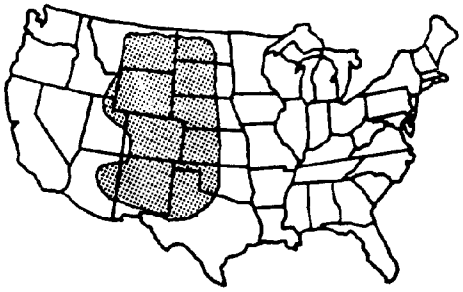


Galleta

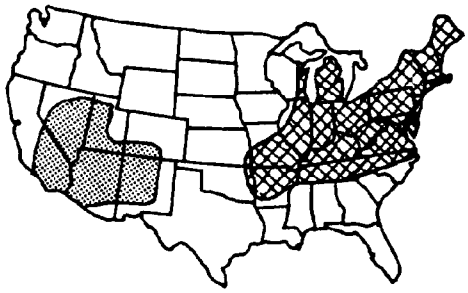
Figure C-3. Miscellaneous grasses; turfgrass alternatives.



Black Grama
Side Oats Grama



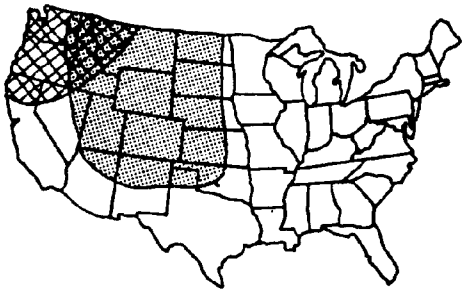
Blue Grama



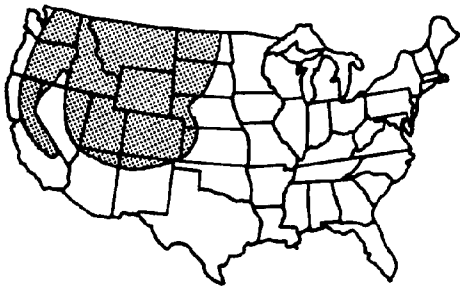
Redtop
Indian Ricegrass



Timothy



Blue-Bunch Wheatgrass
Western Wheatgrass



Crested Wheatgrass

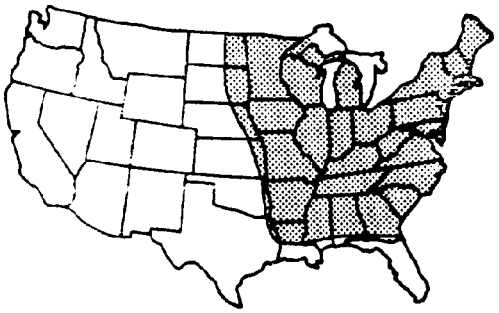
Figure C-4. Miscellaneous grasses continued.

C-4. Figure C-5 illustrates the regional adaptation of some commonly used turf-grass alternatives.

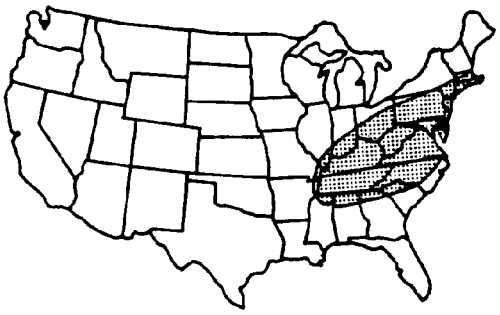
C-5. Computing percent purity. The percentage of pure live seed for most seed varieties is shown in table C-1. For single, unmixed species, the data presented are normally adequate without further computation. For mixtures of two or more seed kinds, compute as shown in the example in table C-2 for a 50-50 mixture of Kentucky bluegrass and chewings Fescue:



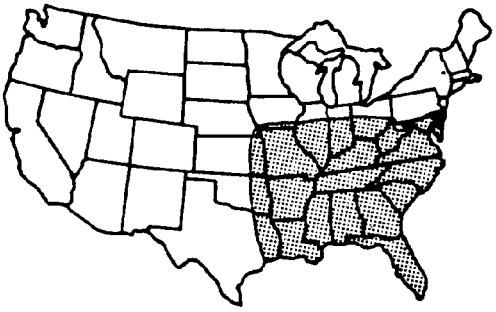
Alsike Clover



White Clover



Japanese Honeysuckle



Lespedeza

Figure C-5. Legumes and groundcovers; turfgrass alternatives.

Table C-1. Seeding rates

	Pure Live Seed %	Weed Seed %	Seeding Rate, lb. 1000 sq. ft. Ornamental Areas	1000 sq. ft. Recreational Areas	Acre Functional Areas Embankment	Acre Functional Areas Airfields	Acre Functional Areas Unimproved
Bahiagrass, Pensacola	50	0.50	---	---	2.0	30	20
Bentgrass	86	0.50	---	---	---	--	--
Bermuda, common*	82	1.00	1.0	2.0	1.0	30	15
Bluegrass, Canada	64	1.00	---	---	2.5	30	20
Bluegrass, Kentucky	68	1.00	2.5	2.5	2.5	30	20
Bluestem, King Ranch	33	2.00	---	---	---	30	20
Bluestem, little**	33	2.00	---	---	3.0	35	25
Brome, smooth	78	1.00	---	---	3.0	30	20
Buffalo+	46	2.00	2.0	2.0	---	25	15
Carpet	83	1.00	---	---	---	20	20
Centipede	30	1.00	0.3	---	---	5	3
Clover, alsike++	87	1.00	---	---	0.2	2	2
Clover, white++	86	1.00	---	---	0.2	2	2
Dropseed, sand	63	1.00	---	---	1.0	25	15
Fescue, chewings & red	78	0.50	3.0	---	3.0	40	30
Fescue, tall	87	2.00	5.0	5.0	5.0	50	35
Galleta**	15	2.00	---	---	3.0	35	25
Grama, black**,+	9	2.00	---	---	3.0	35	25
Grama, blue**,+	26	2.00	3.0	---	3.0	35	25
Grama, side-oats	30	2.00	---	---	---	--	--
Indian ricegrass	45	2.00	---	---	3.0	30	20
Redtop	83	1.00	---	---	2.0	20	15
Ryegrass, annual	88	0.50	---	---	4.0	60	40
Ryegrass, perennial	88	0.50	4.0	4.0	4.0	60	40
Timothy	89	0.50	---	---	---	25	15
Wheatgrass, bluebunch	64	2.00	---	---	3.0	30	20
Wheatgrass, crested	81	1.00	4.0	---	4.0	30	20
Wheatgrass, western	70	2.00	---	---	---	30	20

* Rate based on unhulled seed. Use three-fourths these rates for hulled seeds.
** Data furnished may not be reliable for a specific lot. Seed lot may have much higher or lower purity and germination percents. Adjust seeding rates proportionately.
\+ Rated based on unhulled seed. Use half these rates for hulled seed.
++ Rate based on amount to be used in a seed mixture. Double these rates for pure seeding.

Table C-2. Mixture rate

Seed Kind	*Percent Kind by Weight in Mixture*	×	*Percent Pure Live Seed of Each Kind*	=	*Percent Pure Live Seed in Mixture*
Kentucky bluegrass	50		68		34
Chewings fescue	50		78		39
Total pure live seed in mixture, percent					73
Other than pure live seed, percent					27
					100

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