PARK LANDSCAPE MAINTENANCE HANDBOOK



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National Capital Region

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Division of Maintenance
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PREFACE

There have been many changes since the first edition of the Park Landscape Maintenance Handbook was prepared in 1966; yet many things are the same. Varieties, techniques and handbooks have come and gone. We no longer "Officially" use Class A, B or C levels of maintenance, but when preparing the Condition Guidelines as part of the Maintenance Management System, criteria for satisfactory conditions are considered for each feature, and there is still the attempt to establish a level of maintenance appropriate for each feature in each location. Therefore, we have retained the definitions of these three levels for maintenance managers who wish to utilize them.

This edition has been completely rewritten and reorganized, to incorporate contemporary concerns and technology and to improve its value for current use. Since it is still apropos, and as a tribute to the 1966 Handbook the Forward to it is reproduced, as it appeared in the 1966 edition, as a forward to this edition.

This is the result of the efforts of many people. Chapter Ten was written under the leadership of Adam Badowski. Robert Cook lead the efforts to produce Chapters Six, Seven, and Eight; with a lot of help from James Patterson and John Short. Cynthia Cox wrote Chapter Eleven and the Specifications for Annual Plants. Carol DiSalvo and James Sherald provided Chapter Twelve; with input from Bob Cook on the turf aspects. Chapter Thirteen is the product of Peggy Flemming's effort. James Hauver prepared Chapter Two. John Hoke and Richard Hammerschlag authored Chapter Fourteen. Chapter Fifteen, by Larry Keesen, is reprinted from Grounds Maintenance, with permission. Chapters Three and Four were provided by Darwina Neal. Chapters Five and Nine are the work of Mel Poole.

This is not intended to be a handbook in the traditional National Park Service sense -- it is not a "how-to-do-it" cookbook. Rather, it as a reference work to provide needed information to maintenance managers.

Disclaimer

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PARK LANDSCAPE MAINTENANCE HANDBOOK

FORWARD

The maintenance of the landscapes in the parks comprising the National Capital Region is a never-ending obligation to the public whose interest in and use of these parks continues to increase year by year. The maintenance criteria contained in this handbook pro-vide guidelines for the formulation of realistic programs to meet public use patterns and volumes, the protection of the government's investment and many other strategic considerations. Simply stated, good maintenance means the making of repairs as promptly and as often as conditions warrant, sanitation and trash removal, constant inspection of the landscapes and a ceaseless vigilance that is required to keep the landscapes clean , neat and orderly at all times.

The recognition and acceptance of these responsibilities is just as important as the knowledge and skills required to perform the tasks. While this handbook furnishes some of the technical knowledge required in the performance of the work, it cannot be so all-inclusive as to cover every exact detail. The material contained herein has been carefully screened, condensed and selected to meet most landscape maintenance problems. Much of the data is based upon the experience gained in maintaining the landscape of a metropolitan park system.

Since unlimited resources are not available to perform all of the work contemplated by the objective and the related definition of landscape maintenance, standards have been set taking into consideration the intended purpose of the park development, the type, volume and patterns of public use, public and employee health and safety, visitor convenience, and considerations for the strategic location of the parks themselves. In the interest of efficient management, the quality of materials and workmanship must be the same in all cases, the variables being those relating to the intensity of effort and work plan.

Considering the complex factors involved and the types of parks established, the maintenance effort must be planned, programmed and scheduled under the following classifications:

Maximum Effort of Class A Maintenance

Parks accorded a Class A designation shall be inspected daily by appropriate supervisory personnel. Facilities shall be provided with continuous servicing. Immediate action shall be taken to effect repairs found to be necessary. The maintenance force must be prepared to do immediately that which is necessary to maintain to the highest degree the plant materials and other features of the park.

Intermediate Effort or Class B Maintenance

Parks classified in this category shall be inspected semiweekly by supervisory personnel. Daily servicing of facilities is required. Except where public or employee safety is involved, timely action shall be taken to effect needed repairs. Plants growing in the landscapes should be given whatever attention is necessary to provide for their neat appearance and continued good health.

Minimum Effort or Class C Maintenance

Parks assigned to this classification shall be inspected at least once weekly by the maintenance supervisor. Facilities shall be serviced as often as required by public use. Such repairs as are necessary to protect the government's investment and eliminate hazards shall be scheduled for accomplishment as soon as practicable. The landscapes shall be kept free from trash and debris, plants being provided with whatever attention is necessary so as to suppress disease and control harmful insects.

In planning maintenance work, one must consider the basic fundamentals. In scheduling the work for accomplishment within the frame work of the three classifications given above, the use of common sense and logic are prerequisite. Within each classification, the reader can envision a considerable range not only in respect to visitor impact and pattern, season of the year, but also the economies of the activities carried out in regard to the total maintenance requirements.

The reader must also recognize the fact that within the parks accorded Class B and C designations there may be specific locations warranting a higher classification. The maintenance supervisor must also make provision for the flexibility of the maintenance forces capability which permit immediate and effective handling of emergency situations, as well as meeting situations arising from non-prescheduled events. In addition to the inspections made by maintenance supervisory, continuing inspection and reporting should be made the responsibility of the entire work force in order to detect and promptly report deficiencies observed.

Maintenance procedures, methods and techniques require continuing review, equipment needs must be analyzed, maintenance staffing adjustments made to meet requirements and manpower capabilities properly considered if optimum results are to be achieved.

Finally, a controlled optimum maintenance program can be assured only by providing high caliber supervision and timely inspection of the parks.

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The first impressions most park visitors have of a park, and, hence, the National Park Service, may often be of the maintenance staff. Outside the visitor center or formal tours, the park staff seen by most visitors will be maintenance people. Therefore, it is the maintenance staff who take the first and perhaps can have a good or bad impression with the public. Good public impressions of any organization result in fewer barriers to communication within the community, prevent misunderstanding of park programs, plans and policies, and, more often than not, assure the achievement of program objectives. The maintenance staff can, by its deportment, action and decisions, contribute to the successful implementation of interpretive, research, protection and visitor use programs.

While we can select employees to accomplish the work, we cannot choose the park visitor or neighbor. For this reason, the maintenance supervisor must be extremely careful in selecting someone for employment in the maintenance organization or when assigning tasks to existing employees. Persons being considered should be evaluated not only for their technical knowledge, experience and ability to do the work, but also for their interest in serving the public, their attitude towards conservation and recreation, and their desire to learn and subscribe to Service philosophies and policies. Since the public interacts with Service employees, everyone should be capable of maintaining a good or healthy attitude with the people they serve. Not only must the maintenance supervisor provide training in the technical aspects of the task, but also in a general knowledge of all park programs, objectives and operations in the park.

Maintenance organizations are comprised of many different people with skills and knowledge varying from common labor through professional disciplines. The laborer who picks up the trash and sweeps the walks cannot be expected to answer all inquiries presented by the park visitor. However, even the laborer must know that helping the visitor is a critical part of the job and being polite and courteous are essential. Everyone should have a general knowledge of the park operation and staff, so that even the most technical question from a park visitor can be referred to someone competent to give an answer. All workers should be able to discuss their tasks with the visitors.

Appearance should be as neat and clean as the work will permit. Dress should be appropriate for the task with all appropriate protective and safety gear. Appropriate is the key word; if a task merits use of safety equipment, that task should not be performed when visitors may be affected. Conversely, if a task is not hazardous, do not wear inappropriate safety equipment.

All park employees must remember that it is the American citizen who supports the various parks and programs and many consider themselves to be part owners of the parks. Most citizens regard visiting the National Parks a privilege and appreciate all that is done to make their visit more enjoyable and meaningful. All park employees should be patient and understanding with visitors at all times, even if they become disagreeable. But primarily, remember that all employees should respond in a friendly but professional manner.

The National Park Service must have the active support of both citizens and employees if we are to succeed in carrying out the mandates of our mission. Skillful supervision and management of the maintenance force will materially assist in gaining this support. The achievement of reasonable production goals, cleanliness and good deportment on and off the job serve in a very real way to reduce maintenance and management problems. It also helps to gain financial support for maintenance, interpretive, protection and other park operating programs.

In any field of endeavor, supervisors are judged by visual and tangible proof of the productivity of the work force. To be successful, supervisors must take four primary steps, planning, organizing, directing and controlling, to gain and hold control over the work output. If each is taken carefully and properly, the work can be promptly and efficiently performed. If a step is omitted or judgments are not valid, waste results and the work output decreases.

Not one of these steps can be considered complete in itself. As we can visualize, what is done in one step affects another. This makes the job of getting work done complex but not necessarily complicated. However, complications are encountered by the person who does not give adequate thought or time to the development of plans necessary in controlling the work. Stated another way, each event succeeds or fails in proportion to the thoroughness of the preparation given it. Sketchy suggestions and "half-baked" plans and ideas do not appeal to the wise manager and such plans and ideas must not be allowed to find a place in the planning of those who are engaged in direction or managing any program of the Service. It has been proven under all kinds of conditions that people succeed best who form definite ideas of what they are going to do before they do it. Unfortunately, this precept is generally neglected. We drift then into situations where we find ourselves at the mercy of circumstances.

We suggest for the reader's consideration the following techniques of good planning. These basic guidelines will enable the maintenance supervisor to participate more fully in the managerial activities related to the work.

MAINTENANCE MANAGEMENT

Maintenance Management provides a formalized process and procedures for managing maintenance operations in all park areas. Although the magnitude of the maintenance workload varies from area to area, the same procedures are adaptable to park areas of all sizes and with differing responsibilities. The four major functions of Maintenance Management are:

- Planning
- Organizing
- Directing
- Controlling.

All components of Maintenance Management are developed to reflect maintenance requirements and conditions in all park areas throughout the nation. Maintenance Management provides managers and supervisors with effective procedures to manage and control their maintenance responsibilities. Microcomputers are used to store relevant maintenance data, perform calculations and prepare reports. By eliminating the need for tedious, time-consuming manual tasks, the maintenance staff is available to perform other maintenance work.

The planning, organizing, directing and controlling functions are shown in the flowchart, Basic Maintenance Management Information Flow, on page 3. Each function has several components which are integral to Maintenance Management.

Planning: The planning function provides a Work Program and Budget that reflects management decisions and objectives for park maintenance activities. This process includes the development of several planning elements that are organized and compiled to form a work program and budget. These elements are:

- Organization Data
- Work Activities
- Inventory and Condition Assessment
- Service Levels

- Planning Guidelines
- Resources and Unit Costs.

Organizing: As shown in the flowchart, the organizing elements are:

- Workload Distribution
- Work Calendar
- Resource Requirements.

Workload distribution procedures are used to allocate the total annual work program to the months the work will or should be performed. The need for staffing to match seasonal workload variations is readily apparent from this process. A work calendar to be used for preparing short-term schedules is provided. The monthly requirements for labor, equipment and materials needed to do the annual work program are identified.

Directing: The work-directing function involves identifying and documenting work needs, preparing short-term work schedules and assigning work to the maintenance staff. These elements are shown in the flowchart and involve the use of:

- Work Calendar Status Reports
- Work Requests and Backlog Reports
- Knowledge of other factors affecting maintenance activities.

These work-directing procedures assist the managers and supervisors in their efforts to accomplish the work program objectives in an efficient and cost effective manner.

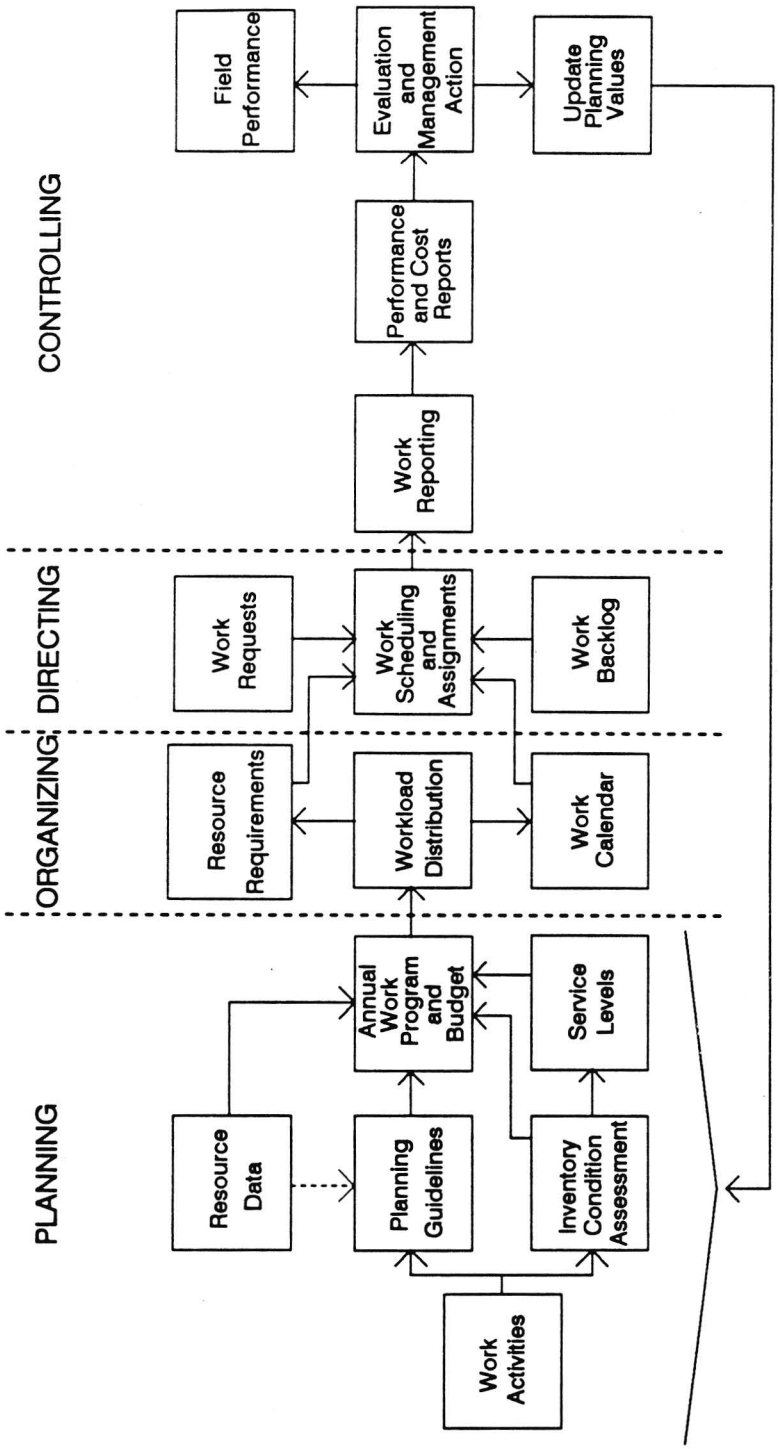
Controlling: The work-controlling function consists of monitoring the progress of work performed in comparison to the plan and taking action to direct or redirect future efforts. Procedures are provided for collecting, evaluating and using work performance data reported by field maintenance personnel.

Work performance and cost reports are available for managers and supervisors to use in analyzing and evaluating maintenance work efforts in their respective park areas.

PARK PROGRAM MANAGEMENT AND MAINTENANCE MANAGEMENT

Maintenance Management provides detailed documentation of the maintenance workload and helps identify when specific activities should be performed. Maintenance Management allows the work program to be easily modified when available funding or other conditions change. Maintenance Management provides guidance in scheduling work and provides more timely and useful information to maintenance managers. Perhaps the biggest difference between general Park Program Management and Maintenance Management is that management gives full consideration to total park maintenance requirements, instead of only those work activities that are considered achievable within the available funding targets. Management attention and management action are focused on work activities instead of on facilities; and the procedures used in controlling and evaluating work programs are directed towards work accountability. Park Program Management focuses primarily on costs and use of funds; whereas Maintenance Management focuses primarily on work planning and accomplishment, as well as the costs associated with specific maintenance activities. With Maintenance Management, maintenance managers have more detailed information and documentation of work programs and can use such documentation to develop the park's current operating program.

Maintenance Management is designed to assist maintenance managers in their efforts to plan, organize, direct and control the park maintenance program through Condition Assessments. This is a tool for managers to use in setting objectives, preparing programs, and carrying out those programs in maintaining landscapes.



Basic Maintenance Management Information Flow

Condition Assessments: The condition of the park landscape features is a major factor in determining where and how much work is needed to maintain the features consistent with park policies and priorities. Because planned maintenance often depends on the condition of a particular feature, an annual condition assessment is necessary. This regular assessment of the park's landscape conditions can be very helpful in preparing a maintenance work program and improving the visual quality of the park.

The condition assessment is based on a comparison of actual conditions of the maintained feature, with the condition guideline developed by the park for that feature, such as roadside mowing, gardens and formal lawns. By comparing the actual condition to a condition guideline, an indication of maintenance needs can be obtained. Such maintenance needs are then used to develop desired service levels; i.e., how much and what maintenance work should be done on the inventory feature, and, based upon these service levels, a more realistic maintenance workload can be identified. The condition rating can also be used to help identify maintenance priorities and to provide an indication of where maintenance attention should be directed.

Assessment Procedure: The condition assessment, for those landscaping features to be rated, is a process of establishing a numerical rating to indicate how closely the current condition of the feature matches the stated guideline.

This process is performed annually or as often as required by the park, so that the most recent conditions and changes can be reflected in the planning process.

Condition Guidelines: The landscape inventory features to be rated are included in Maintenance Management System manuals; this publication and other National Park Service directives are sources of information. Condition guidelines should outline criteria for a satisfactory condition for each feature and location. Various locations within the park will require different criteria and methods of maintenance to insure optimum standards; i.e., the standards for satisfactory roadside turf will be different from those for the turf in a formal garden, and those for native plantings along a nature trail will be different from those for plantings around a formal memorial.

Assessment: With the condition guideline well in mind, the feature is rated. An overall inspection and observation is made and compared with the stated guideline. The assessment is then a numerical rating of how closely the current condition matches that described in the guideline.

A rating of "1" indicates that the feature is in "satisfactory" condition and meets the desired condition guideline. The rating "1" also indicates that (a) routine maintenance should be sufficient to maintain the current condition; (b) cyclic maintenance is not required; and (c) a repair/rehabilitation project is not required to correct feature deficiencies.

A rating of "2" indicates that the feature is in "fair" condition and, although the condition generally meets the condition guideline and provides an adequate level of service to park visitors, the feature needs more than routine maintenance attention. The rating of "2" also indicates that cyclic maintenance or repair/ rehabilitation work may be necessary within the next three to five years.

A rating of "3" indicates that the feature is in "poor" condition, does not meet the condition guideline and is in need of immediate maintenance attention. The rating of "3" also indicates that (a) routine maintenance is needed, perhaps at a higher level of effort, to meet significant safety and legal requirements; (b) cyclic maintenance should be scheduled for the current year; and/or (c) a repair/rehabilitation project should be scheduled, consistent with park priorities and long-term management objectives.

Recording Assessment Ratings: The ratings data are recorded on the Detailed Maintenance Feature Inventory (Form 10-210). The three columns on this form are used to allocate the portion of the Total Inventory that is

rated at each of the three conditions. Generally, the sum of the quantities in these three columns will equal the Total Inventory quantity.

The Summary Maintenance Feature Inventory data sheets serve as the source documents for input to the Maintenance Management computer program.

The Managers who plan well and carry out that plan with courage, intelligence and energy, are well on the way towards becoming superior managers. They will achieve their ends because their beginnings are made with the assurance that comes from knowing the facts, the hazards, and the rewards. It is of no value for a manager to solve a problem and in the process create several more. Conversely, developing and following an orderly plan will result in more problems solved, fewer dollars spent per problem, fewer adverse reactions per problem, less time used, and no random work being done.

Planning itself can be an enjoyable experience, even though its purpose is only to reach something else. Such is necessary if an orderly rate of progress towards meeting the service goals and objectives is to be achieved.

Visual quality is reflected by the image our parks present to the public--their quality of both design and maintenance. The visual quality of even an award-winning park design is severely diminished, if it is improperly or inadequately maintained, but even the highest quality of maintenance cannot improve a poor design, although it can make it look better. The reality is that no matter how "good" or creative a designer thinks it is, a design is no good unless it can be constructed, is functional, and can be maintained at the level of maintenance which it can realistically be expected to receive. In fact, good design is more functional, easier and less expensive to maintain, and even less expensive to construct than "bad" design, since you don't have to spend more money later to correct deficiencies.

Whether a park is newly constructed, rehabilitated, or is as historically constructed, maintenance is the most important factor in ensuring the continued use and effectiveness of any outdoor space. Likewise, maintenance of all elements which form or are within that space is crucial to ensuring the integrity of its design. Thus, it may help to explain the design, construction and post-construction evaluation processes and their relation to maintenance.

DESIGN

Most parks are designed by landscape architects who have professional degrees in landscape architecture. Basically, landscape architecture is, in the case of parks, designing a space for use by people with the least impact on important natural and cultural resources. A landscape design or plan for an area takes into consideration both what is existing and what is needed from a functional standpoint, as well as what would be aesthetically pleasing, and what can be maintained.

Landscape design also involves composing a succession of experiences for people; the basic elements used are land, structures, and plants. Often plants are emphasized to the exclusion of other elements, but successful landscape design can be achieved only by the integration of all three into a harmonious composition.

As people move through a landscape, they are affected by sequences of spaces, views, forms, and experiences which occur along their path of movement. These are created by use of the basic elements -slopes or flat areas, steps, terraces, structures within the landscape, spaces or views formed by vertical structures or placement of plant material.

Of these basic elements, plants provide the greatest number of creative opportunities. Once formed or built, the land and structures stay the same except for wear, but plants are constantly changing - growing, blooming, dying, providing a variety of colors and interest at different seasons.

Different types of plant material are available for various uses and to produce different feelings of scale or character - large or small trees for shade or height; deciduous or evergreen shrubs for massing, screening or color; perennials and bulbs for foreground plantings to provide permanent color; annuals for "fill-in" temporary color; ground cover for underplantings to tie masses together. The scale and character needed to produce the desired effects determine the types of plant material to be used.

The most important principle of design in using all of the basic elements is unity or harmony - not only within a park, but also in relation to its surroundings. Everything within a park must "work together" functionally and visually or aesthetically - for example, walks should lead naturally into paved areas, benches should be placed under trees in relation to walkways, rather than in the midst of a grass area where paths will be worn to them, and the same or complementary materials - whether constructed or natural -should be used throughout. As you look at a park, your eye should flow through it, stopping at designed focal points such as sculptures, rather than jumping between different features and materials that seem out of place.

When this harmony of design has been achieved and the park is well maintained, it reflects the best image to the public, and thus the highest visual quality.

CONSTRUCTION

Visual quality of park areas can be severely adversely impacted by construction projects. Consequently, it is important that project construction specifications include appropriate provisions to protect and/or minimize damage to park resources and visual quality. Examples of such provisions which should be incorporated in construction specifications and/or shown on drawings are as follows:

1. Establishment of limits of work for construction and limits of access to construction site.

2. Need for, location and design of project signage.

3. Need for, location and design of construction fencing.

4. Need for and locations of on-site construction office/shed, temporary toilet facilities, and materials storage areas.

5. Requirements for protection of existing plant materials to remain and replacement of any damaged plant materials.

6. Requirements for on-going project clean-up/litter control and soil contamination/ erosion control.

7. Requirements for site restoration after completion of construction and before project is accepted.

Inclusion of these provisions in the construction documents, however, does not ensure that they will be followed, unless they are enforced by an on-site project supervisor or contracting officer's representative who inspects the work on a daily basis, documents deficiencies, and notifies the contractor of needed corrections. Refer to the Appendix for Division I master specifications which can be adapted to provide adequate construction controls.

Although detailed construction specifications are not usually prepared for construction work done by park personnel, the same concerns should be addressed and enforced by park personnel assigned to supervise each project.

POST-CONSTRUCTION EVALUATION

Post-construction evaluation is important in ensuring the continued effectiveness of any design--that it meets both user and maintenance needs--whether it has been recently constructed, or whether it was constructed 20-30 or more years ago.

Such a re-evaluation may by required because: (1) the intensity and kinds of use and visitation could not be anticipated ahead of time and extensive wear does occur, (2) types and intensities of uses and circulation patterns have changed in the years since the park was constructed, or (3) the existing plant materials are not compatible with existing environmental conditions or uses or have become overgrown or diseased.

In any case, the types, intensity, and patterns of use must be re-evaluated and a design solution developed which will accommodate or refine these changes. Such solutions might include widening paved areas, restricting or channelling access by installing fences or post-and-chain barriers, adding new walks or paved areas, or replacing or adding plant materials. But it is important that the selection and placement of the materials for any solution be compatible with the original design intent and materials.

Such a design solution should be developed by a design professional, usually a landscape architect, in consultation with site managers, interpreters, and maintenance personnel. Appropriate internal and external reviews should

also be conducted before a design solution is finalized. Internal reviews might involve design and natural and cultural resource professionals and higher level managers. External reviews might involve fine arts, planning or historic preservation commissions or boards and community or neighborhood groups, depending on the degree of design change.

Overgrown, difficult-to-maintain, or unhealthy plantings may also require a re-evaluation, especially if (1) they are so overgrown that they are out of scale with adjacent features and/or block views, (2) corrective pruning would ruin their form, (3) part of a single mass-planting has died and replacements are not available in matching sizes, or (4) plants have succumbed to disease or pollution. As is the case with changing uses, solutions for possible planting problems or concerns should also be compatible with the original design intent and materials, and developed by or in consultation with design professionals and the Horticultural Advisory and Review Committee (See Chapter 4) and reviewed before being implemented.

MAINTENANCE OF VISUAL QUALITY

Generally, once a park has been constructed according to approved design and construction plans and specifications, all maintenance and operations efforts should be carried out with the purpose of maintaining the visual quality and design integrity of that approved landscape development plan, site and/or planting plan, as appropriate. Just as a park should be designed for ease of maintenance, that design must also be maintained. Consequently, no changes should be made unless they are discussed/reviewed/approved by the designer, the Horticultural Advisory and Review Committee, park management, and/or other necessary review authorities, as cited under Post-Construction Evaluation.

It is important to realize that maintaining a park as it was designed and constructed means that all replacements/repairs must be done in kind to match type and appearance of existing materials, that no design elements or structures may be changed or eliminated, and that no elements or structures may be added, unless such changes/additions and their design or location are approved. Examples of such changes which must be approved to ensure the maintenance of visual quality/quality of design are as follows:

1. Need for and location of additional quantities of existing design elements, such as benches, trash baskets, planters, and lights.

2. Need for, design and location of new design elements, such as benches, trash baskets, lights, flagpoles, fences or barriers, drinking fountains, and planters.

3. Need for, design and wording of any signs or plaques.

4. Location, size and color of any utility or equipment storage boxes or structures.

5. Need for, location and color of any trash dumpsters or storage containers.

6. Need for, location and material of all new or adjusted walk alignments, steps or ramps, including those for improved access.

7. Need for and location of any materials storage areas.

8. Need for elimination of any of the above-referenced design elements and recommendations for resultant restoration or replacement.

9. Any changes in color or material of design elements or structures.

10. Need for and extent of removal of any plant materials.

11. Need for, kind and location of any changes or additions of plant materials.

12. Any changes in maintenance of plant materials, such as pruning of trees or shrubs, or addition or elimination of meadows through changes in mowing practices.

Most important, if in doubt about any proposed changes or additions to a park design, or about maintenance practices or their effects, ask. If it is in regard to the plants, ask a landscape architect, horticulturist, natural resource manager, Integrated Pest Management Coordinator or a member of the Horticultural Advisory and Review Committee. If it is in regard to design elements, structures, monuments or memorials, ask the designer, an architect, cultural resource manager, or preservation specialist.

Remember, since quality of maintenance is the most important factor in ensuring the continued visual quality and public use of our parks, it is important that what is done with our often limited resources is done well! And it's worth asking to make sure that it's being done correctly.

HORTICULTURAL ADVISORY AND REVIEW COMMITTEE

The Horticultural Advisory and Review Committee (HARC) is responsible for the provision of advice on all vegetation management matters, and the review of all plans that include or affect vegetation. The Committee acts in response to a request from the Regional Director, a superintendent, manager or unit director, or other National Capital Region office; or the Committee may act in response to a need or concern expressed by one of its members.

The purpose of the Horticultural Advisory and Review Committee is to ensure consistency in planning, design and management of vegetation throughout all units of the National Capital Region. The Committee provides advice to the Regional Director, superintendents, planners and other park personnel, as well as A/E consultants, on diverse matters relating to park vegetation.

The Committee consists of a Chairperson, representatives from Divisions of the Regional Office, and representatives from each park unit. The park representative may designate a person trained or experienced in horticulture, forestry or landscape architecture to act in his or her behalf. While the involvement of private citizen representatives is encouraged, the designation of such a member is at the discretion of the park; and the appropriateness of citizen contributions will be evaluated by the Chairperson and the park representative. All committee members are not involved in all Committee actions. For each Committee deliberation, the Chairperson assembles a team consisting of at least two Regional Office representatives and at least one representative from the park or unit requesting Committee involvement. The Chairperson assembles the Committee when the need to meet arises and coordinates participation with the park or Regional Office unit involved.

The following are some specific concerns of the Committee:

1. Review of all planning documents that affect vegetation. Plans must have HARC approval before being implemented.

2. Review of any proposed changes in existing park landscapes, whether or not plans are required.

3. Review of all plant selections in all NCR planting and development plans for:

    a. Form, structural quality and longevity
    b. Insect and disease resistance
    c. Environmental tolerance
    d. Site suitability

4. Review of problem plantings and preparation of recommendations for correction or replacement.

5. Evaluation of hazardous trees and other planting and development of management recommendations for removal, replacement, or specialized maintenance.

6. Assistance in the review of requisitions for procurement of trees and other plant materials as requested by the Regional Director, Contracting Office or park superintendent. The Committee may reject species, varieties or cultivars that are ecologically or culturally inappropriate, and/or make corrections to inadequate specifications.

7. Coordination with the Division of Training to ensure that necessary courses are available for NCR personnel responsible for various facts of vegetation management.

Each park superintendent or site manager is responsible for routine practices, such as removal of storm-damaged or dead trees and replacement in kind, pruning and spraying, site preparation, and the purchase and planting of plant materials. The parks inspect and tag trees, shrubs and other plant materials; however, a park

that does not have the expertise within its staff may request assistance from the Committee or another park. Each park should look to the Committee for regional policy and guidance in carrying out its vegetation-related responsibilities and request assistance to deal with specific problems or concerns.

The Office of Design Services provides design and technical assistance in the preparation of planting plans and recommendations for removal and/or replacement of plant materials, or additions of plant materials, to sustain the design integrity of park areas in conformance with the original design intent. The Office of Design Services also reviews all planting plans prepared by others to ensure high standards of design and appropriate use of plant materials within a design context. Such initial plan review may occur without Committee involvement, but the plan must gain Committee acceptance before final approval.

The Center for Urban Ecology provides scientific and technical assistance on Dutch elm disease and gypsy moth management, plant pest and disease diagnoses, integrated pest management, exotic plants, and soils. The Division of Maintenance Management Agronomist will provide such assistance on turf and turf management issues.

The following persons have been designated to serve, on an ad hoc basis, on the National Capital Region Horticultural Advisory and Review Committee:

Chairman: Don Filsoof, Chief, Division of Maintenance (Regional Horticulturist when position is filled.)

Possible Regional Office Representatives:

Mr. A. John Benjamin, Chief, Urban Coordination and Environmental Impact Division
Mr. Carroll Schell, Resource Management Specialist, Resource Management and Visitor Protection
Mr. Robert Cook, Agronomist, Maintenance Division
Mr. Russell Davis, Contracting Specialist
Ms. Darwina Neal, Chief, Design Services Division
Mr. James Patterson, Research Agronomist, CUE
Dr. James Sherald, Plant Pathologist, CUE
Dr. L. Kay Thomas, Research Biologist, CUE

Park-designated representatives will participate in Committee deliberations regarding areas in each park's jurisdiction.

The NPS authority for vegetation management derives from several sources and determines the type of actions appropriate to particular locations or areas within a park. In addition to the NPS Organic Act which provides a general authority "to conserve the scenery and the natural and historic objects ...therein", a park's enabling legislation may specifically identify plant resources or communities or landscapes that are to be preserved. The Statement for Management or General Management Plan for each park may also set policy for specific types of vegetation management based upon NPS Management Policies (Blue Book Chapters 4 & 5) and NPS-2 Planning Process Guideline (see Appendix V-A). As prescribed by these documents, vegetation management zones and objectives are as follows:

Management Zones	Objectives
Natural	Perpetuation and restoration of ecological processes including the natural abundance, diversity, and integrity of plant communities. Manipulation shall be limited to those activities which seek to restore altered ecosystem processes based upon current scientific research and in accordance with NPS-77 Natural Resources Management Guideline. Prohibited activities include mowing or turf establishment (except for temporary erosion control), tree removal (except for those determined to be hazardous), mechanical removal of underbrush or the introduction of exotic species. Pest management activities are undertaken only to control exotic plant or animal species which threaten native species or natural processes. The control of otherwise noxious but naturally occurring species such as poison ivy is prohibited.
Cultural	Preservation and restoration of the biotic components of cultural landscapes that are important due to their association with personages, events, or periods in human history. Preservation activities should be in accordance with NPS-28 Cultural Resource Management Guideline. It is preferred that each cultural landscape be documented adequately with a Cultural Landscape Report (see NPS-28 Technical Supplement, Chapter 5). Manipulation of cultural landscapes shall be based upon extensive archeological and historical research and shall be allowed only to achieve or maintain an appropriate and authentic cultural landscape or historic scene. Plant materials used in cultural zones should have existed during the documented historic period. The removal of non-historic plant materials from cultural zones is appropriate. Non-historic plant materials may be substituted for historic species when it can be shown that site physiographic factors will no longer support the historic species and provided that there is no significant difference in the visual characteristics of the non-historic species. Exotic species are allowed in cultural zones provided they can be documented as occurring at the site during the correct historic period. Agricultural land use for orchards, vineyards, row crops, or nurseries may be permitted in cultural zones if such site uses occurred during the historic period.
Development	Managed and maintained for intensive visitor use and park administrative needs. This zone allows the maximum amount of landscape manipulation. It is still required that developed zone landscapes utilize plant materials and landscape maintenance techniques that are compatible with the natural, cultural, and landscape design themes of the park.

Intensive landscape maintenance usually occurs in this zone and may include activities such as mowing, turf management, seasonal floral display establishment and other intensive horticultural and arboricultural types of activities in addition to intensive integrated pest management. Landscapes and plantings adjacent to natural or cultural zones will use native or historic species and materials to the maximum extent possible (NPS Policies, Chapter 4, P.9). The establishment of exotic species may be appropriate to this zone only if no other plant species can adapt to the physiographic and sociocultural factors of the site.

Special Use

Managed and maintained by or for other government agencies or private interests in a land use that would otherwise be incompatible to NPS policy. Usually this is the result of some pre-existing legal authority (see NPS-53 Special Park Uses Guideline). While the land use cannot be prohibited by the NPS certain landscape management conditions (eg., screening, mowing, sanitation) can be required as a condition of granting the special use authorization.

Landscape management practices should be appropriate to the management zones in which they occur. It is a supervisory responsibility to inform all park employees of the actions and sensitivities that each management zone requires. Parks are encouraged to develop vegetation management plans that identify management zones and realistically set forth site-specific objectives such as succession, restoration, and intensive landscape management. It is also useful to include small scale topographic maps, aerial photographs, or landscape concept drawings to fully define zone and site objectives. Vegetation management plans serve to assure that personnel are aware of and perpetuate these objectives by orienting new employees to the vegetation management goals of the park and by providing an institutional memory when key employees transfer or retire.

TEXTURE AND STRUCTURE

Soil is the natural body consisting of broken and weathered minerals, decaying organic matter and pore space. It forms the thin layer on the surface of the earth which provides mechanical support and sustenance for plants. The mineral matter consists of the primary soil separates, sand, silt and clay. Sand is the largest consisting of primary soil minerals, such as quartz, which range in size from 2.00mm to 0.05mm. Silt particles range in size from 0.05mm to 0.002mm, and are also predominately primary minerals. Clay is the smallest soil separate, less than 0.002mm in size. Clay consists of secondary minerals which are the decomposition products of primary minerals. The textural class is the name given to each soil based on the proportion of each of the soil separates in the soil.

Sand particles may be either rounded or angular. Unless the particles are coated with silt or clay, moisture has little effect on their behavior. The large particle size results in large pores, or macropores, which allow water to percolate rapidly through the soil, but also results in a low water holding capacity. Sands and sandy soils are usually well drained, often too well, are well aerated and are easily worked. The coarser sand particles typically consist of local rock. Quartz dominates the finer sands, with other minerals accounting for a small fraction of the sand.

Silt particles are irregular and diverse in shape; some soil scientists have characterized silt as microscopic sand. Quartz is the dominant mineral of silt. The smaller particle size and resulting smaller pore spaces causes water movement to be slower than in sand, but the ultimate water-holding capacity is similar. In contrast, clay particles are plate-like in shape. Clay is the active separate in soil. It responds to changes in moisture by shrinking and swelling. Clay and organic matter are responsible for water and nutrient retention. Clay is responsible for the plasticity of soil. The more important clay minerals are aluminum silicates such as kaolinite, illite and montmorillonite.

The names of the 12 textural classes of soil describe the dominance of each of the separate sizes. A soil in which the properties of no one separate dominates is a loam. As the clay content increases, the soil is classified a clay loam and then as a clay. As the silt content increases, the soil is classified a silt loam and then as a silt. Increasing the sand content yields a sandy loam, a loamy sand and finally a sand. Increases in both sand and clay would produce a sandy clay loam or a sandy clay. A silty clay or a silty clay loam would result from increasing the silt and clay.

Since sand and silt are relatively inactive in the soil, very high percentages (70-80%) of the soil must be either sand or silt for the soil to be given that name. Clay, however, is so active that a soil with only 40% clay can be classified as a clay soil.

Modifying the textural class of a soil is virtually impossible, except for potting soil or in small beds, because tremendous quantities of materials are required. Making a coarse-textured or light soil finer or heavier is more practical than the reverse. When attempting to modify an existing heavy soil, enough sand must be added to provide more large pore spaces than the silt and clay in the soil can fill. When attempting to modify a light, soil do not add so much fine material that all the large pore spaces are filled.

Structure refers to the arrangement of primary particles into compound particles or aggregates that are separated from adjoining aggregates and have properties unlike an equal mass of unaggregated primary particles. A soil in which the clay particles are aggregated into larger compound particles has many of the advantages of a sandy soil (good drainage, aeration and workability); and yet retains the water and nutrient holding capacity of the clay.

A fine-textured soil, such as a loam, may have its structure destroyed by manipulation while too wet, an action referred to as puddling, and the resulting soil referred to as puddled. Manipulation may be by plowing or other tillage operation, traffic, grading, loading or any other activity which touches the soil. A soil whose structure has been destroyed is referred to as structureless/massive. There are no large pore spaces and frequently, there

are few, if any, small pores. Roots cannot penetrate such a soil because of the increased mechanical resistance and because oxygen levels within the soil are too low to support root growth. Structureless sands have single grain structure. Because finer-textured soils rely on structure for large pore space, the presence of adequate structure is critical for plant growth.

In the early stages of soil development, either natural or through restoration, a structureless soil will develop vertical cracks. These may be several feet apart and the structure then is described as massive-blocky. Masses of flattened roots can often be found in these cracks. A mature natural soil in the Washington area typically will have granular or crumb structure. Granular and crumb structures are usually found only in soils relatively high in organic matter and are very fragile. The intermediate forms of structure have been named platy, prismatic, columnar, blocky and nuciform. Platy structure is often found in compacted soils and causes the reduced water and air infiltration typical of compacted soils. The individual plates are arranged much like the shingles on a roof, and air and water cannot penetrate except at the edges of the plates.

The shrink/swell cycles associated with wetting and drying of the soil, the expansion/contraction cycles of freezing and thawing and the physical effects of root expansion and animal activity create fractures along lines of weakness, forcing contact between particles and thereby encouraging granulation.

Organic matter, especially that in an advanced state of decay, ie., humus, is the most important single factor in granulation of soil particles. It acts as a binder and its electrochemical properties help organize clay particles into aggregates. Adequate granulation of clay soils occurs only in the presence of humus. The effect of humus is apparently biological, chemical and physical. Green manure or temporary cover crops can be a very effective way to add organic matter to soil.

Calcium tends to flocculate soil colloids, which, if conditions are right, can lead to granulation. Sodium disperses the soil colloids and decreases the stability of soil aggregates or granules. Continued use of sodium nitrate as a nitrogen fertilizer will lead to decreased granulation in the soil. When sodium chloride is used for deicing streets and walks and gets into vegetated areas, the concentration of salt upsets the water balance in the plants and the sodium weakens the structure and makes the soil more subject to compaction.

Tillage alone does not aid in the granulation of soil; in fact, tillage destroys granulation. Tillage makes what granulation is present more apparent. It allows mixing organic matter, lime, fertilizer and other soil amendments throughout the root zone. Tillage can encourage, deeper and wider root proliferation and thereby can aid granulation.

Because structure is the condition of existing soil particles, it can be changed. The factors affecting granulation or aggregation are for the most part natural. To effect a positive change in granulation, those factors which encourage it are accentuated and those having a negative effect are minimized. Management which fosters deep extensive rooting, which assures adequate organic matter, which provides adequate nutrients, especially calcium, and which limits or controls tillage and use, will help to improve the soil structure.

Use, tillage or manipulation when the soil is wet will destroy structure or puddle the soil most effectively. One plowing of wet soil will destroy in minutes the structure that took decades to build. Once the natural structure of a soil is destroyed, the soil will never be the same; the compacted soil of prehistoric settlements shows on modern aerial photographs.

WATER AND WATER MOVEMENT

Soil water is divided into three classes: hygroscopic, capillary and gravitational water. Hygroscopic water is held tightly to the soil particle by hydrogen bonding of the water molecule to the soil particle, and is not available to plants. Capillary water is held at moisture tensions between hygroscopic and field capacity (gravitational water). Capillary water occupies the smaller pore spaces and is the only water to stay in the soil long enough to be considered the soil solution. Capillary water is further sub-divided into inner and outer capillary water. Gravitational water is the water which moves through the large pore spaces in response to the pull of gravity.

Capillary water can move in any direction, but only from wetter to drier soil. Gravitational water only moves downward in response to gravity.

From the plant perspective, hygroscopic and inner capillary water are not available, outer capillary water is available and gravitational water is excess. In a poorly-drained soil, gravitational water is retained and the air is displaced from the pore spaces eliminating oxygen needed by the plant roots. If these conditions are prolonged, the soil becomes waterlogged or anaerobic. These soils are typically more blue or gray in color, have a foul odor, and present an environment hostile to plant roots.

In a well-drained natural soil, there is usually no abrupt change in the soil texture, and water can move relatively freely in any direction through the profile.

SOIL FERTILITY

Fertility of a soil refers to the ability of the soil to supply the nutrients required to sustain adequate plant growth. Soil fertility is not constant, but varies from soil to soil, from one place to another in the same soil, and with time. The plants grown and the yield realized determines whether a soil is considered fertile.

Organic matter and clay are the most chemically active constituents of the soil, and soil fertility results primarily from the release of nutrients from these components during the weathering processes. Weathering of parent material produces soil containing minerals inherited from the parent material. A soil developed from a resistant mineral, such as quartz, will have little native fertility compared to a soil formed from more easily weathered materials, such as limestone. Fertilizers are used to supplement the native fertility of soils.

Soil fertility is also affected by the texture of the soil and by previous use or crops. A sandy soil or a soil with little organic matter will not be as fertile as other soils and could require more frequent, but lighter, fertilizer applications to prevent leaching of the nutrients by percolating water. The previous crop can affect fertility; some crops add nutrients to the soil, while other remove them. Alfalfa, clover and other legumes convert atmospheric nitrogen to nitrate nitrogen in nodules on their roots. In contrast, crops such as tobacco tend to deplete soil nutrients. Intensively managed crops in which large portions of the plant are harvested generally remove more nutrients than less intensive crops of which only a small portion, such as the seed, is removed. Green manure crops are grown specifically to be plowed under to add organic matter to the soil. They are usually rapid-growing plants and are used when the ground would otherwise be bare, pending the next planting season for the desired crop or plant.

Among the nutrients required by plants are carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, boron, manganese, copper, zinc, molybdenum and chlorine. Carbon, hydrogen and oxygen are supplied by air and water; the remaining must come from the soil. Six are required in relatively large quantities and are referred to as macronutrients; these are nitrogen, phosphorus, potassium, calcium, magnesium and sulfur. The others, because they are required in small quantities, are called micronutrients or trace elements. Some micronutrients are toxic to plants if present in excessive quantities.

Nitrogen is the soil nutrient required in largest quantities by plants. It is a major component of protein and chlorophyll. It acts as a regulator and governs the use of phosphorus, potassium and other nutrients. When nitrogen is limiting, the top growth is stunted, younger leaves will be pale green or yellow, older leaves will fall off and root systems will be restricted. An excess or over-supply of nitrogen stimulates vegetative growth at the expense of root growth and flowering. Too much nitrogen also weakens the plants physically, and makes them more susceptible to disease.

Nitrogen (N) is extremely mobile in the soil. Nitrate (NO_3) forms, which are most easily used by plants, are water soluble and leach readily. Ammonium (NH_4) forms are volatile and easily lost to the atmosphere. The more stable forms are complex organic compounds. Because nitrogen is so unstable and variable in the soil it is not included in routine soil tests.

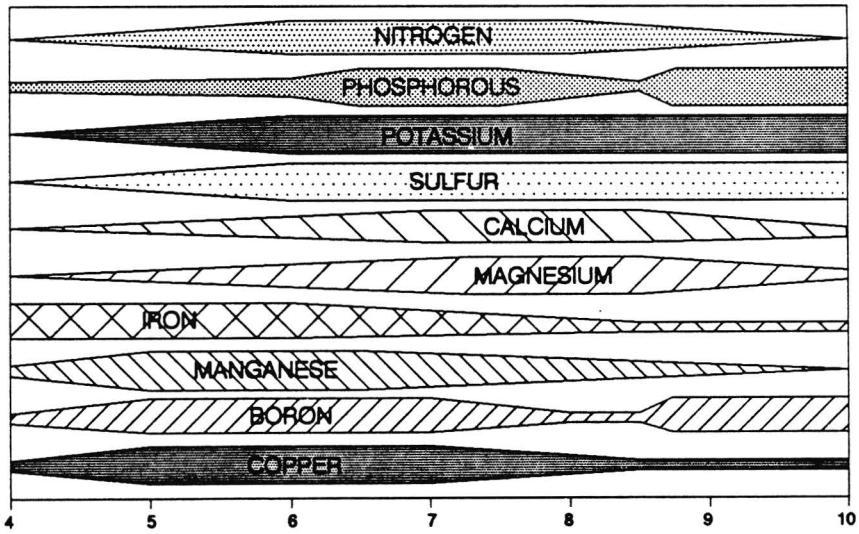
Phosphorus (P) strengthens stems, is essential for floral development, cell division and formation of protein, and is involved in the transportation of carbohydrates. A deficiency of phosphorus is characterized by poor roots, dwarfed plants, and a purple discoloration of stems and the lower sides of the leaves.
Phosphorus is very immobile in the soil and must be thoroughly mixed throughout the root zone prior to planting.

Potassium (K) serves to balance nitrogen and phosphorus in the plant, acts as a catalyst in the formation of starch and translocation of sugar, and is necessary for the formation of chlorophyll. A potassium deficiency causes dry scorched edges and irregular chlorotic patches on leaves (between the veins on grasses). An adequate supply of potassium improves drought, heat and cold tolerance of plants.

As applied in fertilizer, potassium is mobile, but very quickly becomes attached to the clay particles. Therefore, it is also important that it be thoroughly mixed throughout the root zone.

SOIL REACTION

The reaction of the soil is measured in units of pH, which is the negative logarithm of the concentration of hydrogen ions. The pH is reported on a scale of 0 to 14, with 0 being most acid, 7.0 is neutral (neither acid or alkaline) and 14 being most alkaline or most basic. Because pH is a log scale, a soil with a pH of 5.5 is ten times more acid than a soil with a pH of 6.5; and a soil with a pH of 4.5 is 100 times more acid.



THE EFFECT OF SOIL pH ON AVAILABILITY OF SOIL NUTRIENTS.
The width of the band indicates the relative availablity of the nutrients.

The principal effect of soil reaction is on nutrient availability. Iron is more available for plant use at a pH of 5.5 than at 7.0. Phosphorus is most available at pH values between 6.0 and 7.0. The availability of potassium decreases as the pH falls below 6.0. At pH values above 6.5, nitrogen can be lost to the atmosphere as ammonia (NH_3). At low pH values, potential toxins such as lead, cadmium and aluminum are more available.

Two forms of acidity are present in soils. Active acidity is the acidity of the soil solution and is the form usually measured. Reserve acidity results from hydrogen ions held by the soil particles. This gives soil buffer capacity or resistance to change in pH. A sandy soil will have little reserve acidity; a loam will have more, and a clay the most. Therefore, a clayey soil could require three times the quantity of lime to raise the pH from 5.5 to 6.5 as would a sandy soil, and a loam could require twice the amount that the sandy soil would require.

When fertilizer is applied to soil with a low pH, some of the nutrients like phosphorus and potassium are quickly converted to a form which is not available to the plants. If the pH is too high, the nitrogen could be lost to the atmosphere before the plants use it. For fertilizer applications to be effective, the pH of the soil must be within the acceptable range or the nutrients will not be available to the plants.

SOIL AMENDMENTS

Soil amendments are defined as any substance added to the soil to alter soil properties. Soil amendments are used to adjust soil reaction (pH), to alleviate nutrient deficiencies, to increase water and nutrient holding capacity, to encourage aggregation, to add stability to the soil, and to increase large pore space. Some soil amendments affect the soil chemistry; others have more effect on the physical properties of the soil and a few do both.

Among the soil amendments which are chemical in action are fertilizers, lime and gypsum. Fertilizers are used to supply nutrients. Lime serves as a source of calcium and to adjust the pH. Gypsum provides calcium without having an effect on the pH. Calcium is a flocculating agent, and lime and gypsum can have a beneficial effect on aggregation.

Gravel, sand, pumice, scoria and the light-weight aggregates (expanded slate, calcined clay and sintered fly ash) are more physical in action and, when added in large enough quantities, give the soil more large pore space and greater stability. Pumice, scoria and the light-weight aggregates have internal pore spaces and, therefore, some nutrient and water holding capacity. Large quantities (85%) are required to affect the soil texture. Sand should be coarse, approximately 1 to 2mm in size, and all particles should be nearly the same size.

Fine-textured organic soil amendments like peat moss, compost, leaf mold and sawdust affect both chemical and physical properties of the soil. When added to a sandy soil, these will improve the water and nutrient holding capacity of the soil. In an ideal situation, plant roots will replace these organic materials as they decay. Loamy or fine-textured soil also can be mixed with sandy soil, in moderation, to improve water and nutrient-holding capacity. When added to a fine textured soil, organic materials can increase the infiltration rate of water, and as they decay the resulting humus can help aggregation.

Too much organic material added to a loam or clayey soil can result in an excess amount of water being held, and have a negative effect on the soil and plant growth. Coarse organic materials such as wood chips will have an immediate effect, more like the very coarse sand or gravel, but, because they do decay, the long term effect will be more like that of the fine-textured organic materials.

The very light-weight amendments like vermiculite and perlite are frequently used in potting soils, but do not have the mechanical strength for use in other soils.

SOIL TESTING

Periodic soil testing is essential for the economical maintenance of quality turf and other plants, and to realize the maximum benefit of the soil and fertilizer resources. There are commercially available fertilizers which will adequately supply all the required nutrients. These are not generally recommended because they are more expensive than standard fertilizers and because nutrients are being purchased which the soil can normally provide. There is also the possibility of accumulating toxic quantities of unneeded nutrients. Lime can be applied by "rule of thumb", but there is the possibility of applying too much lime, thereby wasting money and leading to alkaline soil conditions; or too little, thus not correcting the problem.

The soil should be tested annually until a stable pattern of management is established and deficiencies are corrected. Soil which responds quickly to fertilization and liming and has limited nutrient-holding capacity should be tested every three years, while soils with greater buffering capacity and nutrient-holding capacity can be tested on a five year cycle. Testing should always precede any renovation. Soil testing is essential to monitor the effects of fertilization and liming on the soil chemistry.

The sample submitted for testing should be the composite of at least 8 sub-samples taken at random throughout the sample area. The area from which the sample is derived should be as uniform as possible in use, condition, characteristics and history. Areas which do not meet all these criteria should be sampled separately, even if they are the same lawn, bed or field. If the sample does not accurately reflect the area, then the recommendations for that area will not be valid.

Local state universities provide soil testing either free of charge or for a nominal fee. This is usually available through the local county extension agent, who will provide sample containers and a questionnaire about the area to be tested. The results will include phosphorus, potassium and magnesium levels, pH, an estimate of the textural class and general recommendations for lime and fertilizer.

EROSION CONTROL

Erosion is the removal of the earth's surface, usually in the form of soil, by glacier, wind, or water. Removal of a uniform thin layer is sheet erosion, while a series of small channels is rill erosion. Rills develop into gullies, which can vary from several inches deep to the size of the Grand Canyon. Sheet erosion is frequently not conspicuous, except that the stones and pebbles often will be left on pedestals of soil.

Erosion is a naturally occurring process, partially responsible for the creation of soil from geologic materials. Natural erosion is a slow, steady evolutionary process and is often unnoticeable. In contrast, disturbance of natural landforms by man's activities tends to produce rapid, erratic and drastic erosion. Our goal must be to manage the soil resource so that erosion more nearly approaches a natural rate.

Erosion is harmful in many ways. Soil is transported from its original location, leaving depressions in the surface, voids, or undermined plants and structures. The soil is deposited at a new location further downwind or downstream, where it may cover desired features or clog waterways. In addition to the physical deposits of soil particles, the fertilizers, pesticides, and other chemicals and fertilizers lost by erosion are a major non-point source of water pollution and are believed to be a major contaminant of the Chesapeake Bay.

The most effective method of erosion control is a healthy, vigorous vegetative cover. This may consist of a lawn turf, perennial groundcover, shrubs, or mature forest. Many studies have shown that vigorous, well-fertilized turf areas show less soil loss and chemical run-off than thin, under-fertilized turf.

Contour farming or contour strips are agricultural techniques, used to combat erosion in cropped fields, in which undisturbed bands of vegetation are left in place across the slope, and in which the tillage and planting also occur across the slope. Working across the slope, rather than up and down the slope minimizes the formation of down-

hill channels by intercepting and reducing the velocity of water moving down the slope, and the undisturbed areas provide filter strips to catch any soil which might erode. Despite the effectiveness of these techniques, their usefulness in a park setting is limited, except for special situations such as during restoration of an historic scene, where strips of woods would be cleared and revegetated, with the remaining land cleared and revegetated after establishment of vegetative cover in the previously-wooded strips.

Tilling across the slope will have wider application. Whenever land is tilled, the first and last tillage should be across the slope. Planting should also be across the slope to ensure the small ridges are left to intercept and reduce the velocity of water flowing downslope. Sod, seed, bedding plants, and shrubs can all be planted across the slope.

On larger projects, where the economy resulting from the use of seed for revegetation is required, much of the erosion protection of sod can be achieved by sodding the areas most subject to erosion, such as banks and swales, and laying occasional strips of sod across longer slopes to act as filter strips. Seed can then be used for the more level surfaces and between the sodded sections.

Mulches are beneficial by protecting the soil from erosion, and providing a more favorable environment for vegetation establishment. The types of mulches available vary from cellulose fiber, applied to the soil surface, to open concrete blocks placed into the soil. Shredded bark and wood chips simulate the natural organic layer (duff) at the soil surface of a forest, and help to prevent erosion in shrub and tree planting.

Cellulose fiber is typically applied to the final soil surface as part of the slurry when seeding hydraulically (Hydroseeder); thus it is easy and cheap to apply. However, it is the least effective mulching material available.

Straw has been used for years. It can be machine applied and can be secured with asphalt or other tacker. The tacker can be applied with the straw, or it can be applied later. A network of string can also be used to anchor the straw to the soil. The effectiveness of straw mulch for erosion control is directly related to how well it is secured. Care should be exercised to use clean straw to reduce the introduction of weed seeds.

Mats or quilts of paper, straw, excelsior and other fibers are now available for erosion control. These come in a variety of weights (thicknesses) and costs. The heavier weights are more effective and more expensive. These mats are usually anchored by burying the ends at the top of the slope, and with long staples at the lower end and at manufacturer specified intervals in between. The netting and stitching holding the mats together should be degradable in a few months; otherwise, they can linger on the soil and create liter and maintenance problems.

Jute matting is another alternative. It is made of rope-like strands of jute woven into a mat. Jute mats are anchored much like the quilts. They are longer lasting than the fillers for the quilts, but still decompose after several months.

For extreme situations, where water velocity will be high or where heavy but infrequent traffic is expected, such as firelanes or overflow parking, plastic or concrete blocks (grass or porous pavers) can be used. Commercially available grass pavers or decorative cement building blocks have been used.

Gabions are another form of erosion control for use in areas where other types of erosion control are not suitable, such as along stream banks. Gabions consist of plastic coated wire baskets placed along the bank, filled with rock or other suitable material, and wired together. Properly installed, gabions provide a long term attractive erosion control solution where other materials are not rigorous enough.

Some success has been reported using biotechnology or bioengineering techniques for erosion control. Bioengineering involves using live plants to form the structural members of an erosion control system. Unrooted plant parts are incorporated into the bank, providing soil stabilization similar to that obtained by other

techniques. As the plants become established, the new root systems spread through the stabilized soil providing further stabilization.

Erosion control may be required at construction projects to prevent siltation of neighboring bodies of water. Bales of hay or straw have been installed around construction sites to trap water borne soil particles and to filter the water before it enters a stream or other body of water. Current technology favors properly installed erosion or sediment fences for this purpose. This must be accomplished in compliance with local codes.

SPECIES AND VARIETY SELECTION

Grasses suitable for lawn turf are generally divided into two groups based on their season of most active growth. They are warm season grasses and cool season grasses. Among the warm season grasses are bermudagrass, zoysiagrass, centipedegrass and St. Augustine grass. The cool season grasses include bluegrass, fescue, ryegrass and bentgrass. Because tall fescue will grow at higher temperatures than most cool season grasses, it is sometimes considered an intermediate grass. The intermediate nature of tall fescue makes it well suited to this area.

Most of the parks of National Capital Region are located in the "Crabgrass Belt". This is a zone running southwest from the Delmarva Peninsula to western South Carolina and beyond. The climate is too warm in the summer for the cool season grasses and too cold in the winter for the warm season grasses. The off- season for the cool season grasses is shorter than it is for the warm season grasses; therefore, cool season species are favored, except for special cases.

The warm season grasses grow only during the summer and usually turn brown in November and do not green-up until May. The cool season grasses can grow any time the ground is not frozen and will frequently have some green color all year; however, most growth occurs in spring and fall.

Bluegrasses: Kentucky bluegrass (*Poa pratensis*) is the most useful as a turf grass. It is a long-lived perennial grass which spreads by rhizomes (underground stems) to form a strong sod of medium texture and density.

Kentucky bluegrass will grow in a variety of soils, but prefers slightly heavier, very slightly acid soils with medium to high fertility. It requires abundant water for rapid growth, but a well established plant can survive a drought of several weeks. Growth has been recorded at temperatures as low as 40‘ F, but practically stops, and the plant becomes dormant, as temperatures approach 90‘ F. The optimum temperature range is 60-70‘ F.

Kentucky bluegrass is not especially tolerant of chronic wear, but will tolerate occasional very heavy wear. The recuperative capacity of Kentucky bluegrass is very high during optimum growing conditions. It will be at its best in very open shade or when shaded a small portion of the day. Grown in the wild, it will reach heights of 3 feet. Mowing less than 2 inches will weaken Kentucky bluegrass and shorten the life of the turf.

Several varieties of Kentucky bluegrass are available. To protect the consumer from unscrupulous dealers who would sell inferior varieties as common Kentucky bluegrass, Kentucky and South Dakota have certified that seed sold as certified 'Kenblue' and 'South Dakota Certified' is genuine old-fashioned Kentucky bluegrass.

'Merion' was the first improved Kentucky bluegrass variety. It was found near No. 17 tee on the Merion Golf Club in suburban Philadelphia. Merion tolerates closer cut and is highly resistant to leaf spot when compared to common Kentucky bluegrass. Other weaknesses have greatly reduced its popularity today. 'Wabash' is a selection from Indiana which was selected for extreme drought tolerance. 'Midnight' is noted for its dark blue-green color. 'Monopoly' and 'Enmundi' have done well under lower maintenance levels. Others have been selected for disease resistance, for low habit of growth, for shade tolerance and other factors.

Other species of bluegrass of some importance are Roughstalk bluegrass (*P. trivalis*), Canada bluegrass (*P. compressa*), Bulbus bluegrass (*P. bulbosa*) and Annual bluegrass (*P. annua*).

Roughstalk bluegrass spreads by short stolons (above ground creeping stems). It tolerates wet soil and is sometimes suggested for shade and low maintenance areas. During cool damp weather it is aggressive and invades open sunny areas; however, it thins and turns brown during periods of heat and drought stress. Because of the stoloniferous growth habit and light green color, its appearance is similar to bentgrass when it invades a Kentucky bluegrass turf.

Canada bluegrass spreads by rhizomes, but sparse leaf development prevents forming a high quality turf. It is tolerant of shade and dry infertile soil.

Bulbus bluegrass is a small bunch grass which spreads by bulblets and looks like a miniature onion. It can be found in many older areas and is more important as a curiosity than as a turf grass.

The species *P. annua* has been split into two sub-species; one is a true annual, the other is not. Both are small, low growing, bright yellow green bunch grasses. In a lawn, they should be considered weeds, but they can produce a respectable turf when cut short and watered well, as on some golf course situations.

Fescues: For turf purposes, the fescues are divided into two groups; fine fescue and coarse fescue. The fine fescues are more important and widely used in the Philadelphia/Wilmington area and further north, where they are valuable shade grasses. The value of these in the Crabgrass Belt is limited, but as much as 20 percent should be included in mixtures for shade. 'Pennlawn' is the standard variety. Hard fescue and sheeps fescue are sometimes included as nurse grasses in wild-flower mixes. The fine fescues prefer lower fertility levels than most grasses. Fine fescues are easily recognized by their pine needle-like leaf and gray-green color.

The coarse types useful for turf are all tall fescue (*Festuca arundinacea*). 'K-31' was for many years the only variety suitable for turf. As isolated plants or in a thin stand, the leaves tend to lay flat and become very wide and coarse. When grown as a thick turf, the leaves are forced to grow more nearly vertical and are much narrower. Tall fescue that is well established is more tolerant of continuous light wear than most bluegrasses. It also is more tolerant of lower fertility and lower pH. Tall fescue will remain active at high temperatures and lower soil moisture than bluegrass; thus it appears to be more drought-tolerant, but in reality it is less, because it will extract soil moisture to the permanent wilting point and die. Several turf-type tall fescues are being marketed. The prime advantage of these is that the leaf is slightly narrower. With moderate maintenance they can provide a higher quality turf with greater density and wear-tolerance than K-31. 'Rebel II', 'Wrangler', 'Finelawn 5GL', 'Finelawn I', 'Adventure', and 'Thoroughbred' are turf types which have done well in NPS trials; other recommended varieties are 'Apache', 'Arid', 'Bonanza', 'Falcon', 'Houndog', 'Jaguar', 'Mustang', 'Olympic' and 'Rebel'.

Ryegrasses: In the past, the primary use for ryegrass (*Lolium* spp.) was as a nursegrass in seed mixtures, because of its rapid germination and seedling vigor. While this did result in quick cover, the competition of the ryegrass usually delayed the establishment of the desired permanent species. The development of improved perennial ryegrasses (*L. perenne*) has led to a change in the role of ryegrass. A blend of three improved perennial ryegrasses can be very effective for over-seeding warm season grasses, for temporary cover, when seed must be used at the wrong time of the year, or where abuse makes repeated renovation essential. When used in mixtures with Kentucky bluegrass, ryegrass should not constitute more than 20 percent of the mixture, and the rate of seeding the ryegrass should not exceed 1/2 pound per 1,000 sq.ft. Ryegrass should not be seeded with tall fescue. As a group, the ryegrasses are less tolerant of wear than tall fescue and have low recuperative capacity.

Bentgrasses: The use of bentgrass (*Agrostis* spp.) is limited to golf courses and other very intensively managed turfs. 'Redtop' (*A. alba*) has been used as a nursegrass, but its use has been discouraged because of its highly competitive seedling growth and its unsightly appearance and persistence. Bentgrass seed occasionally appears as "other crop" in uncertified tall fescue seed. When bentgrass becomes established in a bluegrass or tall fescue turf, it has an aggressive, patchy, creeping habit of growth. The resultant turf is thatchy and easily scalped.

Bermudagrass: Bermudagrass (*Cynodon dactylon*) spreads rapidly with stolons and rhizomes. Seed of common bermudagrass is available. The texture and color of common bermudagrass are highly variable. A respectable summer utility turf can be made with bermudagrass, however, like other warm season grasses it will be brown several months in the winter. Many people feel that the winter color is less objectionable if cool season grasses and winter weeds are controlled so that the brown is more uniform.

Several improved bermudagrasses have been developed, but none are winter-hardy enough to be recommended in the Washington area. Even common bermudagrass can be expected to suffer significant winter-kill every 8-10 years. In warm seasons, bermudagrass is very tolerant of wear and can recover quickly. In cold seasons, it is very sensitive to wear and does not recover at all.

Zoysiagrass: The zoysiagrasses (*Zoysia* spp.) spread by rhizomes and stolons but most varieties spread very slowly. Until recently, all were propagated vegetatively. The high labor requirement and slow spread have curtailed the popularity of zoysiagrass. Established zoysiagrass lawns tend to be thatchy when fertilized and are difficult to mow.

Z. japonica is the coarsest-textured and most cold-tolerant of the traditional zoysiagrasses. The common variety is sometimes known as Japanese lawngrass. The most widely used variety is 'Meyer' and most zoysiagrass lawns seen in the Washington area are Meyer. 'Matrella' (*Z. matrella*) is finer textured than but less cold-tolerant than Meyer and few lawns of this have been established this far north. 'Emerald' zoysiagrass, a hybrid of *Z. japonica* and *Z. tenuifolia*, forms a more attractive turf than Meyer but is less cold tolerant than Matrella.

A new seeded variety of zoysiagrass has recently become available. It is much less dense than the vegetative varieties and has shown promise when grown as a mixture with tall fescue. The zoysiagrass dominates in hot weather and the tall fescue in cold. For this mix to succeed, both most survive all year. There is some evidence that the tall fescue warms and protects the zoysiagrass so that fall color retention is longer, and spring green-up is earlier, in the mix than alone.

The zoysiagrasses are very tolerant of traffic during the warm season; however, they recover very slowly. Tolerance to traffic in the cold season, when the zoysiagrass is dormant, is extremely low. One of the objectives of the zoysiagrass/ tall fescue mix is to provide cool-weather wear-tolerance especially in early spring.
Other popular warm season grasses adapted to more tropical climates than Washington are bahiagrass (*Paspalum notatum*), St. Augustinegrass (*Stenotaphrum secundatum*) and centipedegrass (*Eremochloa ophiuroides*). None of these are sufficiently cold hardy to survive in the Washington area.

SOIL PREPARATION

Tillage or soil preparation can be for one or more purposes. It can be to control, remove or eliminate the existing vegetation which will compete with the desired species. Incorporating soil amendments such as lime, fertilizer, organic matter or other soil modifiers is effectively accomplished with tillage. Tillage serves to loosen and breakup hard or compacted soil; this effect is temporary, but essential to let roots develop to some depth, and facilitates removal of rocks and other debris. With loosened soil, it is easier to achieve a precise grade. Tillage allows seed/soil contact.

The most important consideration in soil preparation is soil moisture. The range of soil moisture during which tillage can be done without seriously damaging the soil is very narrow. If the soil is too wet, structure is destroyed and hard lumps created. If too dry, the structure again will be destroyed, resulting in a powdery surface which is subject to erosion and crusting. Either condition leaves a soil more prone to compaction. In addition to being hard on the soil, tillage attempted when soil moisture is not near optimum is more difficult and requires more power. It must be remembered that even under optimum conditions no known tillage operation improves soil structure, but only makes the existing structure more apparent.

Several tools or machines are available for tillage and soil preparation; the choice for each job will depend on the size of the area, the relative importance of each of the purposes of tillage, the terrain, and personal preference.

Moldboard plow: The old standard, the shape perfected by Thomas Jefferson, accentuates the granulation or structure by its lifting, twisting and shearing action. It also, by its twisting action, inverts or partially inverts the furrow slice and turns under surface material and vegetation. Thus, it is quite effective in incorporating surface-applied soil additives.

The moldboard plow has some serious drawbacks. Continued use creates a hardpan or plowsole at the bottom of the furrow. The surface is rough and uneven. Soil is moved the width of a furrow to the side. Power requirements are high. Plowsoles can be broken by occasional deep tillage; varying the depth of plowing will help prevent or delay development of a plowsole. Following plowing, a disc harrow and spike or spring-tooth harrow effectively smooths the surface and can be used to further incorporate soil additives. In an agricultural situation where exact grades are not critical, the movement of soil to the side can be counteracted by plowing the first time in one direction, and plowing the second time in the opposite direction. This movement can also be used to build terraces, swales, crowns and other low profile soil structures. The high power requirement which is reflected in fuel costs is best controlled by plowing only as often as necessary and doing it only when soil moisture is ideal. In spite of the drawbacks of the moldboard plow, it is not as damaging to the structure as rotary tillage and should be used more often in major renovation projects.

Disc plow: Disc plows are substituted for moldboards on stony or rocky soil. Their action is similar but not as efficient.

Disc harrow: This is a series of small disc plows, usually set up in pairs, one throwing to the right, the other to the left. They are most commonly used to follow the plow to break larger clods and to level the ridges left by the plow. A disc harrow is effective in incorporating soil additives which should be nearer the surface. On a friable soil, the disc harrow can be the first step in tillage. It can also be effective in breaking up organic matter on the soil surface prior to plowing.

Spring-tooth harrow: These are useful as a finishing tool in agricultural fields where a very smooth surface is not needed. Hitching a board or piece of chain link fence behind a spring- tooth harrow will produce a surface acceptable for most park applications. Spring-tooth harrows tend to bring the stones or other objects in the soil to the surface.

Spike-tooth harrow: The spike-tooth harrow is less aggressive than the spring-tooth; therefore, it produces a smoother finish and is less likely to bring things to the surface. The chain link fence or board drag will further smooth the surface.

Rotary tiller: Rotovator and rototiller are two of the more popular names for rotary tillage machines. Rotary tillage is a very drastic form of tillage. It is very effective at mixing top-to-bottom of the furrow. Horizontal movement of soil is not a major concern. The power requirement is very high, but this is partially offset by the fact that one or two passes can produce a finished seed bed. Rotary tillage tends to produce a fluffy seed bed which requires some time to settle before planting.

There is a tendency to over-till, especially when trying to achieve deep tillage in a dense soil in poor physical condition. This destroys what little structure was left and leaves a soil which can easily become puddled and even more dense. In many cases, using a moldboard plow and harrow would achieve as good a seedbed and do less damage to the soil.

Thatcher/seeder: When the primary purpose of the tillage is to provide seed/soil contact, a thatcher/seeder is recommended. This would be the case if there was a significant amount of desirable vegetation left. Various other turf cultivation tools and a seeder can substitute for a thatcher/seeder.

Key points to remember when tilling soil are;

1. All tillage destroys soil structure,
2. Tillage only makes existing structure more apparent,
3. The soil must not be either too wet or too dry when tilled,
4. Till only enough to achieve the purpose of the tillage.

TURF PROPAGATION

Once it is decided to establish a new turf or extensively renovate an existing area, the method of accomplishing this most be determined. Several methods of propagation are available; there are advantages to each. Not all methods are available for all species. For example, if it has been determined that an area will be resodded, the choice of grasses must be made from those that are available as sod; or, if a bluegrass blend has been chosen, it must be determined if that blend is available as sod or if it must be seeded.

Sod: That sodding produces an "instant lawn" is based more on sales pitch than fact. Sod must be protected for two weeks or more after laying, before even limited traffic is permitted. It takes one to three months for the roots to knit into the site soil, and watering in the early stages of establishment frequently creates a wet, unstable soil condition.

Sod can be laid any time the soil can be worked; however, knitting will be quicker when conditions are favorable for vigorous growth. Sod is readily available only of Kentucky bluegrass and tall fescue. A few growers will have limited amounts of bentgrass or zoysiagrass. No sod is produced of the fine fescues or ryegrasses. Sod growers favor those varieties which establish rapidly in full sun; these may or may not be the best for your location.

Sod carries with it a layer of soil. This forms a moisture barrier in the soil and has the potential of introducing new weeds, diseases and insect pests.

Sod is expensive. Sod costs approximately $1.50 per square yard in 1988. Seed for the same area cost less than 10 cents. Estimators figure on a 6-person crew installing 1,000 square yards of sod per day; whereas, 1 person can seed 1,550 square yards per day. Soil preparation should be the same for either sod or seed.

Seed: Establishment of a turf from seed is slower than from sod; the time it must be protected can be counted in months. Bluegrass seed takes 2-3 weeks to germinate, tall fescue about 6-10 days, and ryegrass 4-6 days. Soil moisture is critical for germination and during the first few weeks after germination.

The time frame during which seeding can be done with a reasonable chance of success is limited. The most desirable time to seed is late summer and early fall (August 15 - October 31). The next best time is late winter on frozen ground. Spring rates a poor third, and risk increases rapidly as the season progresses. Sowing seed other times is too risky.

The choice of species and variety is wider than with sod. Mixes or blends can be custom-made for the site using grasses which might not be available as sod. The seed is planted directly in the native soil with none of the problems associated with imported soil on sod. Direct establishment costs are less than for sod. However, follow-up and early maintenance costs will partially offset this.

Vegetative: This type of propagation is usually limited to those grasses which do not produce quantities of viable seed or the seed does not yield offspring like the parent. Zoysiagrass, hybrid bermudagrass and many creeping bentgrasses are the types most often propagated vegetatively. Sodding is a special case of vegetative propagation.

One method is sprigging; pieces of rhizomes or stolons are inserted into the soil. These plant parts are collectively referred to as sprigs. Sprigs are prepared by harvesting specially grown sod and shredding or chopping the sod into sprigs. These are perishable and should be planted as soon as possible. Sprigging can be by planting a rhizome or stolon with 2-4 nodes, 2 or 3 inches deep, but so that a portion is above ground. Machines designed for this can be used or the sprigs can be broadcast and pushed into the ground with a notched stick. One to four bushels per 1,000 square feet are required. Stolonizing is a variation of sprigging, the sprigs are broadcast over the area, covered with a thin layer of topdressing or soil, then rolled and watered. Five to ten bushels per 1,000 square feet are needed.

The other vegetative method is plugging. Small pieces of sod are planted on 12 to 16-inch centers. This is a compromise between sod and sprigs; it is cheaper than sod and less risky than sprigs. Time to complete cover is longer. However, plugs can be set into an existing turf, with a gradual transition to the new grass.

Except as noted for plugging the soil preparation should be the same regardless of the method of propagation.

MOWING

No turf maintenance operation affects the appearance of the lawn more quickly or dramatically than mowing. Mowing is the heart of grooming the lawn; a well-groomed patch of weeds can present a pleasing appearance, while a poorly-groomed turf of the finest grass available will not look good. It is one of the few operations that a worker can finish and get immediate satisfaction. Without mowing, most turfgrasses will grow to heights of 2 to 3 feet. Limiting the plant to 2-3 inches or less puts tremendous stress on the plant. It is incumbent that mowing practices and equipment minimize this stress.

A sharp mower that gives a clean cut will do less harm to the turf and result in a better appearance. A dull mower will leave a ragged, frayed end which will turn brown two or three days after mowing. This frayed cut also allows easier entry for disease-producing fungi.

No more than 1/3 of the leaf area should be removed in any one mowing. When more is removed, the plant suffers severe shock, tender plant parts are exposed, the growing point can be injured, and the plant's capacity to photosynthesize is greatly reduced. Under certain conditions, one close mowing can be fatal. At best, the turf is weakened and may be susceptible to invasion of weeds and diseases.

In order to reduce the adverse affects of mowing, the mowers must be sharp and set to cut as high as possible and still achieve an acceptable appearance, but never lower than 1½ inches. Two to 2½ inches would be preferred. Warm season grasses can be mowed slightly lower than cool season. Thus, with a mower set at 1½ inches, mowing is called for when the grass reaches a height of 2 inches (2 X 2/3 = 1½) or when it has grown 3/4 inch. Similarly, at 2 inches, mowing is due when height is 3 inches or it has grown 1 inch and with the mower set at 2½ inches, mowing should be done when the grass is 3-3/4 inches high or has grown 1 inches. Assuming the grass is growing at a rate of 1/8 inch per day, weekly mowing is required at 1½ inches, but at 2½ inches mowing every 10 days is adequate.

Clipping removal is not recommended. The clippings produced by a well (not excessively) fertilized lawn turf will decompose within a month, will not contribute to disease, will help control weeds, and will recycle nutrients, thereby reducing fertilizer requirements. Care should be exercised to avoid piles of clippings. Wet, too tall grass is most likely to produce piles of clippings.

Mowing height should not be adjusted seasonally. Granted, the cooler weather of spring and fall make the grass more tolerant of closer mowing; however, the more rapid growth rate demands more frequent mowing at these times of year, without lowering the cut which also requires more frequent mowing. In other words, lowering the cut in spring and fall hits the grass and/or the mowing program with a double whammy.

The preferred configuration for mowing with a side-discharge mower is zig-zag. This reduces clipping piles, because half the clippings are cut twice, into smaller pieces and there is no net movement of clippings. Round-and-round mowing with the discharge to the inside will move clipping to the center and create a windrow; the discharge to the outside will tend to lay clippings on top of the mowed grass. Configuration with rear-discharge and reel mowers is less critical.

As much as possible, mowing patterns or direction should be varied at least every other time. This helps prevent soil compaction from wheels following the same path every mowing. Also, all mowers, but especially reel mowers tend to produce a grain in the turf; i.e., the stems face the same direction. Varying the pattern reduces the formation of grain. Football fields are frequently mown with the same pattern to produce a grain which emphasizes the yard lines. If budget or other constraints force lengthening the interval between mowings, the height of cut should be raised.

A well-groomed turf is the product of timely mowing with sharp, well-maintained mowers, not the product of close cutting. The lower the height of cut, the more often mowing will be needed. The mowing schedule should be adjusted to the growth rate.

FERTILIZER

Fertilizers are soil amendments which provide the nutrients that the soil is not able to supply. By law, in most states, a fertilizer must supply nitrogen, phosphorus or potassium (potash) or a combination of two of more of these. The package is also required to include the net weight, the brand name, the grade, the guaranteed analysis, and the name and address of the manufacturer. The net weight, brand name, and name and address of the manufacturer are easily understood.

The grade is the three prominent numbers separated by dashes, such as 10-5-5. The first number is always nitrogen, the second is always available phosphorus, and the third is always soluble potash. These are always whole numbers. Many fertilizer recommendations are given in terms of a fertilizer ratio. The ratio is the grade reduced to the lowest possible number; thus, a grade of 10-5-5 will have a ratio of 2-1-1. Other 2-1-1 fertilizers are 16-8-8 and 14-7-7. When converting from ratio to grade, rounding-off is permitted; a 10-6-4 or a 21-10-10 are also 2-1-1 ratio fertilizers.

The guaranteed analysis restates the grade giving the minimum percentage of nutrients claimed and is stated in the following form and order:

Total Nitrogen (N)	_____percent
Available Phosphoric Acid (P_2O_5)	_____percent
Soluble Potash (K_2O)	_____percent.

The guaranteed analysis for nitrogen may be subdivided to include the source or other characteristic of the nitrogen carrier used.

Many fertilizer packages will also include a term like, "Acid Equivalent" followed by a number. Most fertilizers will increase the acidity of the soil; this number is the amount of limestone ($CaCO_3$) needed to correct that acidity.

Nitrogen Sources: Plants use primarily nitrate (NO_3) nitrogen and to a much lesser extent ammonium (NH_4) nitrogen. Any source must breakdown to one of these forms before the plant can use it. Nitrogen sources or carriers are separated into two main groups, based on speed of that breakdown.

The nitrogen from chemical, inorganic, readily or quickly available carriers is usable by the plants within a few days of application. Excessive rates of these is more likely to "burn" the turf. The slower-acting carriers have been labeled organic, slowly-available, long-lasting or the preferred term, controlled-release nitrogen. Problems can arise from words or phrases like chemical, inorganic, organic, slowly-available and long-lasting. All are chemical of some sort. Readily available forms are of both organic and inorganic origin. Weather conditions can affect the rate of release. Modern technology has produced liquid forms of controlled release nitrogen. Selected nitrogen carriers are characterized in Table F-1.

Phosphorus Sources: Rock phosphate, superphosphate, bone meal and ammoniated superphosphate are the most common sources of phosphorus. For most plants, there are no differences among the carriers; economics and convenience for the formulator are usually the most important considerations in selecting a phosphorus carrier. Bone meal, which also contains a small amount of nitrogen, is a natural organic and is popular for ornamentals, especially bulbs, and potting soil.

Potassium Sources: Muriate of potash (KCl) is the most widely used source of potassium. Potassium nitrate (KNO_3) is used in high nitrogen fertilizers. Potassium sulfate (K_2SO_4) is specified for crops like tobacco which cannot tolerate chlorine. Except as noted, there is no agronomic reason to select one over the other.

Table F-1. Characteristics of Selected Nitrogen Sources or Carriers.

Ammonium nitrate	Inexpensive, quickly available
Ammonium sulfate	Acid forming good for azaleas, source of sulfur
Sodium nitrate	Sometimes available as by-product, sodium makes soil more subject to compaction
Urea	Synthetic organic, inexpensive, quickly available
Urea-form(U-F)	Urea + formaldehyde, first controlled release, expensive, rate depends on amount of formaldehyde and microbial activity
Sulfur coated urea (SCU)	Porosity of sulfur and water determine release, moderate cost
IBDU	Slightly soluble, particle size and water determine release rate, moderate cost
Milorganite	Natural organic, micro-nutrients, expensive, low analysis
Cottonseed meal	Natural organic, low analysis, also P and K
Formlene, Fluff, CoRoN	Liquid controlled release made for lawn care industry, expensive, release rates not well documented

FERTILIZATION

The nutritional health of the grass is dependent on a fertilization program derived from sound soil test results. Fertilizer feeds the roots which in turn provide nutrients to the leaves and stems. Roots of cool season grasses are fed by emphasizing fall and winter fertilization and eliminating spring applications. Fertilizer should not be applied to cool season grasses in March or April; this will promote top growth at the expense of root elongation, weaken the plant and increase mowing requirements.

Fertilizer should be applied in the beginning of September, the middle of October, and the end of November or early December. One pound of nitrogen per 1000 sq.ft. should be supplied with each application. In the absence of a soil test, a high nitrogen, low phosphorus, medium potash fertilizer (3-1-2 ratio) will meet the immediate needs of the turf. A one-half rate application can be made in mid-May to darken the color of the grass.

When budget or other restrictions do not allow all four applications of fertilizer, omit them in this order; May, November/December then September. If the soil has adequate reserves of phosphorus and potassium, a straight nitrogen fertilizer can be used. Farm grade fertilizers are often cheaper than lawn or turf fertilizers. Fertilizers

with nitrogen from controlled-release sources are more expensive than those deriving their nitrogen from readily-available sources.

Warm season grasses should be fertilized in March and May and again in July if needed. Each application should supply one pound of nitrogen per 1,000 sq. ft. A fertilizer with a 3-1-2 ratio of nutrients should also be used for the warm season grasses, unless a soil test indicates that another ratio is more appropriate.

If an appropriate-ratio fertilizer is available with 50% or more HWIN (hot water insoluble nitrogen), the fertilizer requirements can be met with two applications, each providing 1½ pounds of nitrogen per 1000 sq.ft.

Topdressing with screened composted sewage sludge at 50 cubic yards per acre (3/8") may be substituted for one fertilizer application. This would be desirable, because compost provides desirable organic matter and micronutrients to the soil and turf.

LIME AND LIMING

Lime serves as a source of calcium and magnesium and counteracts the natural acidity of the soil. Normally liming for acidity control provides sufficient calcium to meet the nutritional needs of the turf and, because calcium is a flocculating agent, it will help to loosen the soil. If the soil test identifies a magnesium deficiency, dolomitic limestone is used. The specific lime requirements for any area can only be determined by a soil test. A pH of 5.5 is the lower limit of the acceptable range for utility turf. The use of turf areas in the National Capital Region dictates a higher standard of maintenance; therefore, it would be prudent to strive for a minimum pH of 6.0. Fescues are more tolerant of lower pH than bluegrasses.

Lime recommendations are usually given in terms of the calcium carbonate ($CaCO_3$) equivalent (C.C.E.) in either tons per acre or in pounds per 1,000 sq.ft. Calcium carbonate is the active ingredient of limestone. Other liming materials include hydrated lime (CaOH) and oxides of calcium (CaO) such as quick lime, burned lime, caustic lime, lump lime or unslaked lime. Ground shells, marl (bog lime), slag and waste lime are locally available liming materials which, if processed and priced properly, can be used.

The calcium carbonate equivalent is expressed as a percentage of the neutralizing power of calcium carbonate; therefore, calcium carbonate is 100, more powerful liming materials will have a higher number and weaker, a lower number. The minimum C.C.E. for quick or burned lime is 140; for hydrated lime the minimum is 110. Limestone, slag and ground shell may have a C.C.E. of 80. Many manufacturers will include the C.C.E. as part of the label. Dolomitic limestones also contain dolomite or $CaMg(CO_3)_2$. The neutralizing power of dolomite is greater than that of calcium carbonate; therefore, a high grade dolomitic limestone could have a C.C.E. of more than 100.

The speed with which limestone, slag, and ground shells neutralize soil acidity is dependent on the fineness to which they are ground. Limestone should be fine-ground or pulverized; this is limestone which has been ground so that all pass a 20-mesh sieve and 75 percent will pass a 100-mesh sieve (Definition C-6). Shells need only be ground so that 50 percent will pass a 100-mesh sieve. Timing of lime applications is less critical than any other turf maintenance operation. Lime can be applied any time of the year, but late fall or early winter is preferred because the rain, melting snow, and freeze-thaw cycles all help work the lime into the soil. There is also a slight advantage to applying lime immediately following aerification. Lime should not be applied within a week of fertilization. One ton per acre or 50 pounds per 1,000 sq.ft. is the most that can be safely applied to turf at one time without turf injury. Any area requiring more than this should be treated with pulverized limestone at 1 ton per acre or 50 pounds per 1,000 sq.ft.; additional increments of lime should be applied at 3 to 6 month intervals until the total requirement is met.

The most economical way to apply lime is to contract with the supplier to spread directly from his trucks. This eliminates bags and excessive handling.

If the dust from the lime is a concern, pelletized limestone such as Ampel or Baker's Commercial may be used. The latter is a pulverized limestone treated with water to reduce dust. Either of these will cost more than commercial pulverized limestone. Baker's Commercial will be slightly more expensive and nearly dust free; the pelletized Ampel will be most costly but will be the most dust free.

Any liming product should also conform to state and Federal laws and to Definition C-6 of the Association of American Plant Food Control Officials and contain 90 percent calcium carbonate equivalent.

IRRIGATION

As with mowing, no set schedule can be given for watering. Normal rainfall is sufficient for survival of the cultivated grasses in the eastern U.S. During drought periods, or periods of extremely high temperatures, supplemental water may be necessary. Watering to alleviate drought conditions should not begin until available soil moisture is depleted and the first signs of water stress are apparent. Water stress is indicated by a bluish-grey color, limp wilted blades and footprints showing after someone walks on the grass. The soil should be examined to confirm that the wilting is due to lack of moisture. Then water should be applied to wet the soil throughout the root zone. It is expected that this will require 1/2 to 3/4 of an inch of water. Depth of water penetration and root zone should be checked with a soil probe. The total water application, natural plus irrigation, should never exceed 1 inch per week.

If runoff occurs before adequate penetration is achieved, as is likely on compacted soils, irrigation should stop until the excess water has soaked into the soil. As soon as the surface has dried, irrigation can be resumed. A smaller nozzle will reduce the rate at which water is applied if runoff is a chronic problem or the irrigation can be cycled on and off, as 30 minutes on, 1 hour off, 30 minutes on etc. until the necessary amount of water is applied. In this era of impending water shortage, and the need to conserve, runoff should be avoided.

The time of day is not important, except that it should be completed early enough so that the leaves are dry by nightfall. When heavy-use events are scheduled, irrigation should be planned to follow that event, rather than precede it. A slightly dry turf and soil have better resistance to heavy traffic or other abuse than a wet turf and soil. A very light watering in the early afternoon will cool the grass in periods of high temperature.

In addition to wasting water, excessive irrigation displaces the air in the soil, increases the ease and likelihood of compaction, and favors disease-causing fungi. Soil air is essential for healthy roots. Excess water in the soil loosens the bonds between particles and provides a lubricant between the particles so that the soil is less able to resist compaction. Very wet conditions, especially when combined with high temperatures, create an ideal environment for the natural soil-inhabiting pathogenic fungi to flourish and infect the weakened turfgrass.

Applying water faster than the soil can absorb it, that is irrigating to produce runoff, has the potential to carry nutrients and pesticides from the turf to pollute water-ways or deposit them where they are not wanted. Runoff water on streets and walks creates a slippery surface, in addition to the nuisance of walking on the wet surface, and the danger of being splashed by passing vehicles.

Except for special circumstances and as noted above, the key words in water use are "long," "slow," and "seldom."

If maintenance is to be deferred, watering should be the first operation to be deferred.

Watering is not a substitute for proper fertilization, adequate liming, or rational mowing practices.

AERATION

Continued use of turf areas, whether ballfields, picnic areas, vista, or even overflow parking, leads to soil compaction. As was discussed in Chapter Six, reversal of compaction is a very slow process. Aerification is an attempt to improve the rooting environment, by making it easier for air and water to enter the soil, while the natural structure-building processes proceed. The most popular machines for aerification can be divided into three classes: vertical punching, rotary coring (conventional) and shatter.

Vertical punching: Vertical punching is most common on golf course putting greens; these machines drive a series of vertical probes straight down into the soil and remove many small cores of soil. Because of the weight of the mechanism to drive the probes, these machines are usually effective to the length of the tine or probe. However, they are slow and the tapered tine tends to glaze the surface of the hole and thereby negate some of the benefits. The cores can be pulverized with a vertical mower or drag and the soil returned, to the turf or they can be removed with a sweeper and disruption of the surface kept to a minimum. Typical of this class are the Toro 'Greens Aerifier' and the Ryan 'Greenaire'.

Rotary coring: Rotary coring machines have tines or probes on discs or a drum which rotate as it is pulled across the turf. Several different styles are available; slicing knives, coring probes and open spoons are the most popular.
Slicing is most effective in cutting through thatch to facilitate water movement and hasten its decomposition, but has no effect on compaction.

Coring probes are similar to the vertical punching, except that the probe enters the soil at a forward angle, rotates and exits at a backward angle. It removes a core like the vertical punch, but the rotation reduces the glazing and gives some displacement and shattering action. Cleanup is the same as vertical punching, but the surface will be more disturbed.

The open spoons are preferred for general lawn turf use. The action is the same as the coring probe except that no core is removed and the displacement and shattering effect is greater. Both the coring and open spoon tines come in several sizes; the larger are more effective, but do not penetrate compacted soil as well as the smaller, and are more disruptive to the surface. Typical conventional aerifiers are the Jacobsen '590' and '595' Aerators, the Hahn Aerifiers and the Ryan 'Lawnaire' and 'Tracaire'.

Shatter: Shatter aerifiers have heavy solid tines mounted at an angle on an axle or shaft. The axle can be angled on the frame to increase the soil displacement action of the tines. These machines are simple, rugged and easy to maintain. The disruption and effectiveness can be controlled by adjusting the angle of the axle; with the axle close to perpendicular to the direction of travel, the depth of penetration will be greatest, but shattering effect and surface disruption least. With the axle set at the widest angle, the shattering effect and surface disruption will be maximized, and depth of penetration slightly reduced. In fact, with a wide angle axle setting, added weight, and several passes, a seed bed can be prepared with a shatter aerifier. The mode of action is similar to the open spoon with displacement to the side, in addition to toward the rear. This increases the shattering. The Holland Equipment Aerway or the John Deere Shatter Aerators, both made by Holland Equipment, are shatter aerifiers.

The Verti-drain is a combination vertical punch/shatter aerifier. The tines are driven into the ground much like the vertical punch, but instead of pulling straight out they are angled to the rear before being withdrawn, thus producing the shattering effect. This machine is capable of deep aerification in clean soil. It is not cost effective in debris and stone laden urban soils.

For general park aerification, either the conventional aerifier with open spoons or the shatter aerifier is preferred. Soil moisture is critical for effective aerification. A dry soil will resist penetration. A wet soil will glaze, be subject to more compaction, and will compress rather than shatter. The best time to aerify is when soil moisture

is slightly below field capacity. This soil will be soft enough to permit penetration, but dry enough to prevent excessive glazing.

When working with severely compacted, soils an effective approach is to start with a conventional or shatter aerifier as for general park use, follow this with a deep irrigation, and then, as soon as any excess water has drained or evaporated use the Verti-drain. For any aeration to be successful, the soil moisture must be correct and the grass must be growing with enough vigor to recover quickly. Frequency of aeration will range from once every several years to 3-4 times each year, depending on the seriousness of the compaction problem.

RENOVATION

Periodic or cyclic renovation of turf areas should be anticipated. The frequency could vary from every 2 years to 20 years or more, depending on the use of the area, the level of care, how well it was established, weather extremes and many other factors. A soil test should always precede renovation to determine lime and fertilizer needs. The degree of renovation required could vary from little more than overseeding and rest, protection from traffic and use, to complete rebuilding (establishment), starting with regrading.

If desirable species account for 50 percent or more of the surface and the grade is acceptable, then aerification, lime (if needed), fertilizer, overseeding, water and rest would be an appropriate level of renovation. If the grade is not acceptable, or the desirable species cover less than 50 percent of the surface, rebuilding by plowing and regrading is more appropriate. Refer to Chapter Seven - Lawn and Turf Establishment.

Overseeding: Overseeding can be an effective renovation technique when the turf has been thinned by abuse or other severe conditions. The overseeded species must be compatible with the existing grass. Varieties of the same species can usually be overseeded successfully. A slow establishing seedling such as Kentucky bluegrass does not do well when overseeded into a vigorous grass like tall fescue. Grasses with vigorous seedlings, such as perennial ryegrass and tall fescue, can be overseeded into almost any thinned turf.

Overseeding should not be used as a substitute for adequate fertility, proper pH, or other maintenance deficiency. As with any renovation procedure, it should be preceded by identification and correction of the cause of the failure, and soil testing. Direct seed-soil contact is essential for germination and establishment of the overseeded grass plant. Thatcher/seeders such as the Jacobsen 548-100 or 524-100 are efficient tools to provide the soil preparation that will give reasonable seed-soil contact. Aerifiers, vertical mowers, thatchers and even hand rakes can also be used. The rate of seeding should be the same as for establishment of new turf.

Regardless of the degree of renovation performed, seeding should be done in late August or early September and no use permitted for several months or until the turf is well established. The timing for laying sod is less critical, and use can be permitted in a few weeks.

It is very important that water and fertilizer levels be maintained during the renovation period.

SUMMARY

Lawn areas should be fertilized 2 or 4 times each year with a total of 3 to 3½ pounds of nitrogen per 1,000 sq.ft. per year. Three pounds should be applied in the fall and early winter. Do not fertilize in early spring.

Mowers must be sharp, set no lower than l½ inches. Water deep and seldom.

Use must be controlled. Play on fields must be prohibited when the soil is too wet. Periods for maintenance and recovery must be provided.

Thin or weed-infested areas should be overseeded in late summer or early fall.

A sound PR program will be beneficial to the success of this program.

REFERENCES

Musser, H. B.; TURF MANAGEMENT; Mcgraw-Hill (U.S. Golf Association), 1950. Oldie but goodie, first to treat turf management as a science, there is a later edition.

Beard, J. B.; TURFGRASS: SCIENCE AND CULTURE, Prentice-Hall Inc., Englewood Cliffs, NJ., 1973. Most complete text, highly technical. $42.00.

Sprague, H. B.; TURF MANAGEMENT HANDBOOK, The Interstate Printers and Publishers, Inc., Danville, IL., 1970. Very good, home-owner level. $25.25.

Turgeon, A. J.; TURFGRASS MANAGEMENT, Reston Publishing Co., Reston, VA., 1980 (First edition). A nice general text, well illustrated. Revised edition. $42.00.

Daniel, W. H, and R. P. Freeborg; TURF MANAGERS' HANDBOOK, 2nd edition, unknown, should be good. $32.95.

Decker, H., and J. Decker; LAWN CARE: A HANDBOOK FOR PROFESSIONALS, unknown. $36.00.

Vengris, Jonas, and W. A. Torello; LAWNS, Third Edition, unknown. $25.95.

All except Musser are available from; Book Sales, Edgell Communications, One East First Street, Duluth, MN. 55802.

More than any other landscape element, trees provide the most prominent visual component in the landscape. Tree preservation and management involves the protection of the three basic structural components of all trees: roots, trunk, and canopy.

The canopy is composed of the leaves, the primary site for photosynthesis and the energy production center for growth and reproduction, and the branches which are the supporting structure for the leaves. In addition to containing the major portion of the vascular tissues (xylem and phloem) through which nutrients and water are transported from the roots to the canopy, the trunk(s) is the major above-ground support for the canopy. The roots are the below-ground portion of a tree which withdraw moisture and nutrients from the soil environment for transport to the leaves, while also anchoring both the trunk and the canopy.

METHODS OF TREE ESTABLISHMENT

Succession: Trees are established through the elimination of all management practices such as mowing, agriculture, etc. Some seedbed preparation may be required and control of exotic species is essential. Used primarily in the management of natural areas to assure the establishment of native species.

Reforestation: Usually used when large areas are to be placed in tree cover. Numerous small seedlings, sometimes called liners, are planted utilizing specialized tools. Weed control is required during the first several years after establishment. This is an especially useful technique for the restoration of utility and road corridors.

Landscaping: Planting method utilized to implement a design plan that emphasizes individual plants in particular groupings. Sites can range from very small to large acreage projects. Major inputs of landscape management are required to maintain these areas which are often highly formal or highly urbanized spaces.

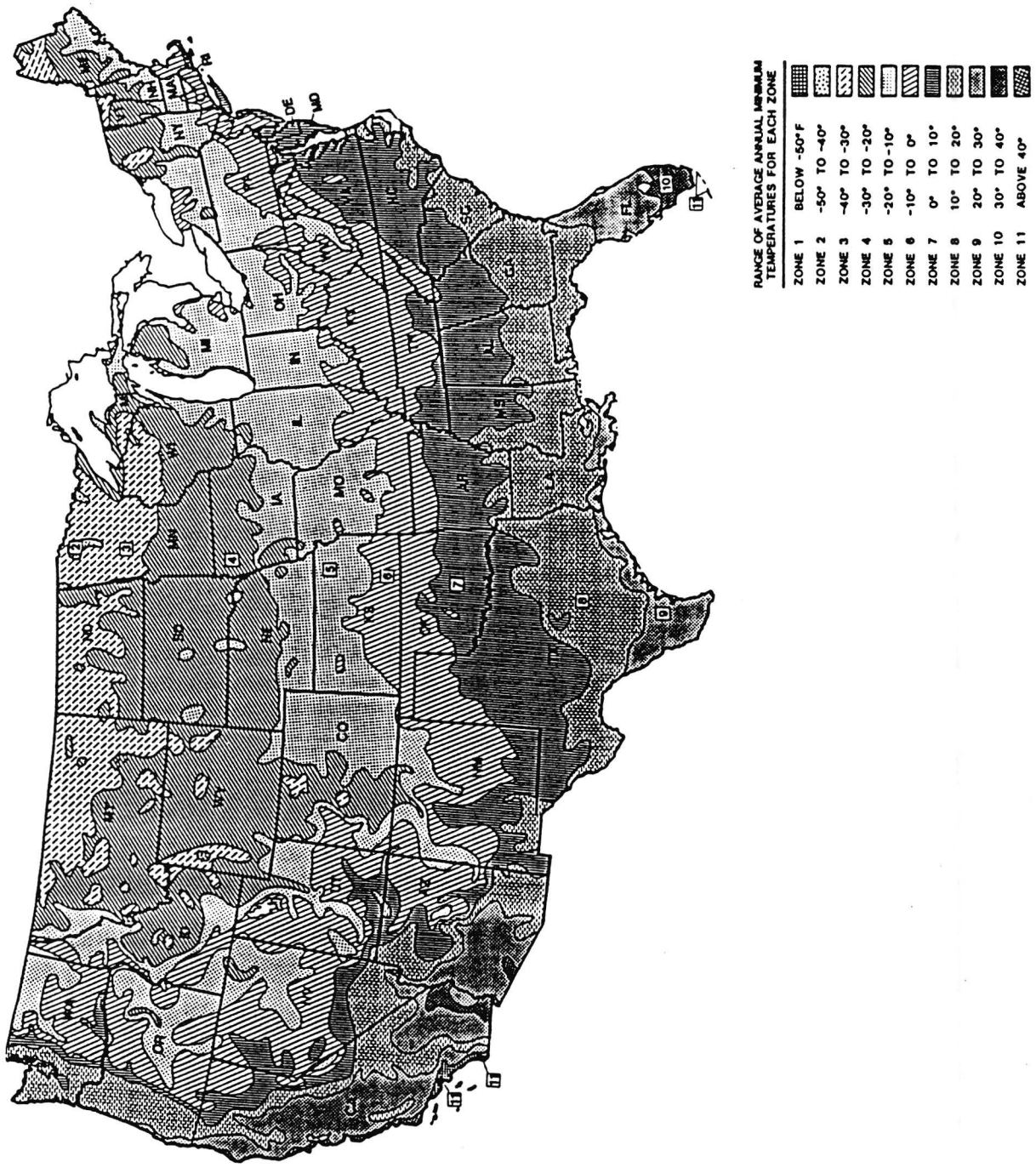
PLANTING SEASONS

Planting of trees is usually undertaken during those times of the year when air temperatures are less than the maximum, soil temperatures are above freezing, and water, in the form of rainfall, is more plentiful. In the National Capital Region this occurs during two periods in the spring and fall from approximately March 1-May 15 and September 30-December 15. These periods may vary by up to two weeks depending upon exact site locations and annual variations in temperature and rainfall. Specific plant species may be limited to a particular season in the spring or fall due to certain growth characteristics.

TREE SIZE AND QUALITY

Trees purchased for planting should meet all requirements and recommendations of the American Standard for Nursery Stock (ANSI Z60.1-1986). They should have a normal growth habit with full, vigorous, and uniform foliage; a sound and well-set root system; and be free from evidence of insect or disease infestation or physiological weakness. Experience has shown that the maximum size of trees for successful transplanting is 2-2,5 inches in trunk caliper. Caliper is the trunk diameter measured at a point 6 inches above the root crown.

To insure maximum cold hardiness, plants should be grown in and purchased from nurseries in Plant Hardiness Zones 6 and 7 as specified in the U.S. Department of Agriculture Map of Hardiness Zones of the United States and Canada.



Plant-hardiness zones in the contiguous United States and southern Canada show the range of average annual minimum temperatures. (USDA 1960).

LANDSCAPE INSTALLATION

Dimensions of tree pits are related to the size of the root ball. The minimum excavation should be one foot wider than the horizontal dimension of the ball and six inches deeper than the vertical dimension. For example, a 2 inch caliper shade tree with a standard root ball that measures 24" x 16" will require a tree pit that is 36" x 22" in size. At the time excavation of the tree pit is completed, soil amendments such as lime and fertilizer should be added to the existing soil. The tree is then carefully placed in the tree pit and soil is slowly added to assure that the tree remains in an upright and perfectly vertical position. The top of the root ball should remain at or above the ground level to assure adequate aeration and drainage. Soil should never cover the top of the root ball. It is better to err on the high side.

The soil should be foot-tamped during backfilling followed by watering which floods the tree pit and forces any remaining air to the surface. This will assure that the soil contains no air pockets adjacent to the root ball that could fill with water and result in root die-back .

Fertilization and Nutrients: Prior to any nutrient application, a soil test should be taken to determine specific needs of any given site. After initial planting, trees are usually fertilized as a byproduct of turf fertilization. It is important that soil pH be maintained at 6.0-7.0 to assure that nutrients will be available for root uptake. If trees are to be fertilized separately, the preferred N-P-K ratio is 3:1:2. For example, a typical tree fertilizer would have an analysis of 18-6-12. Slow or controlled release fertilizers in packet form are preferred for tree fertilization.

Mulching: Mulching of trees is important to provide temperature insulation and moisture retention to the root systems of young trees. Also mulch may provide limited protection from foot traffic and mower damage at the base of trees. A depth of two inches of coarse
organic matter is usually adequate. It is important not to apply more than three inches of mulch as this may entice the tree to send out roots into the mulch layer and jeopardize its ability to develop the deep roots that are needed to withstand periods of drought.

Pruning: At the time any tree is planted, pruning should occur to maintain a balance between the root system and the canopy and reduce the shock associated with transplanting. This involves the removal of the secondary lateral branches. The central leader of the tree should not be pruned.

Periodic removal of dead and broken branches improves the appearance and structure of trees, but more importantly eliminates breeding sites for insect and disease organisms. It is desirable to remove branches that may be crossing or rubbing with another. Branches which exhibit a narrow angle of attachment (less than 45 degrees) to the trunk should be removed because vascular tissues are compressed within the branch and structural failure of the branch becomes more likely as the tree ages. Also it is important to thin the canopy of trees having an abundance of foliage to remove wind resistance and limit storm damage or to allow sunlight to filter down to aid in turf development. As a general rule, pruning done in the spring will serve to increase foliage growth, while fall pruning enhances flowering.

Cuts should be made outside the branch collar to promote healing. Flush cuts, while aesthetically more pleasing, will not heal as quickly. Large limbs should be removed in a three cut process in order to prevent bark stripping. Pruning paints inhibit wound healing and should not be used except in a thinned down mixture when it is aesthetically important to camouflage fresh pruning cuts.

Wounds to the basal area of trees should be treated by removing torn and ragged material and carving the wound into the shape of an oval to promote healing.

All pruning work should be conducted according to The American National Standard for Tree Care Operations (ANSI Z133.1-1982).

Tree Wrapping, Staking and Guying: Tree wrap, also known as kraft paper, should be used as a protection against sun scald on newly planted trees, especially thin-barked species, such as red maple, and those which are planted on south-facing slopes. Wrapping should be done from the base of the tree upward, with an overlap of one half of the width of the material. It should be secured at the lowest branch with twine. While tree wrap provides limited protection against trunk boring insects, experience has shown that tree wrap should be removed at the end of the first growing season to avoid possible deposition of other insect egg masses under the paper wrapping. Where trees may be subject to mower damage, it is advisable to require the additional use of a plastic trunk protector such as "Trimmer Guard."

The purpose of staking and guying trees is to prevent those swaying motions of the canopy that would cause any movement of the root ball. Movement of the root ball inhibits root formation. Staking and guying of shade trees and evergreen species should be undertaken when the height of the tree exceeds 4 feet or the caliper of the trunk exceeds 1.25 inches. Guy wires should be located above the lowest branches and securely fastened around the trunk. The tree bark should be protected from damage by enclosing the wire in a section of rubber hose. Guy wires should be removed one year after the planting date. Failure to remove guy wires can result in the girdling of the tree trunk and subsequent death.

Watering : A tree is a water system that takes its water from the soil through the roots and passes it through the trunk to the leaves where it is evaporated into the air through a process known as transpiration. Dissolved in the water are minerals in the form of starches and sugars that constitute the food that allow trees to grow. The amount of water evaporated from the leaves should never exceed the amount taken in by the roots. If such an imbalance does occur for an extended period of time, nature will intervene by reducing the evaporating surface of the tree through leaf wilting and branch die-back.

Wilting and die-back can be prevented only through supplemental watering during periods of drought. Normal maintenance practices require that all newly planted trees be watered every two weeks during the driest periods of the first summer after planting to ensure their survival. Many trees will survive after the first year without additional watering. There may, however, be particular species or exposed locations that will require supplemental watering for up to three years. In urban settings with intensive heat from pavement and glass surfaces, irrigation systems may be an absolute necessity for the long-term survival of trees and should be considered vital during the development of new projects or the rehabilitation of existing sites.

TREE PROTECTION MEASURES

Tillage or cultivation to promote turf establishment should not take place within the drip line of trees as this causes substantial injury to tree roots.

Repeated nonselective herbicide applications such as Round-Up should be avoided, as toxicity to root systems and subsequent foliage damage may occur.

Trees should be protected against construction damage by installing fencing beyond the drip line (edge of canopy) of the tree. Where possible, groups of trees should be protected by a single fence. Equipment or material storage should also occur outside the drip line of trees.

Trees in the National Capital Region are subject to intensive visitor use. Over time this use can have severe impacts on specific locations. The sequence of intensifying use includes the following:

1. Compaction begins to change the soil.
2. Groundcover materials such as turf are lost

3. Shrubs and small reproduction or understory trees are lost.
4. Older and dominant trees become "stag-headed" --tops die back.
5. Areas become so impacted that users begin to turn to other locations and the site is either abandoned, if hazardous trees have developed, or restored, usually at great expense.

To break this cycle, it must be spotted early and landscape management (fertilization, pruning, etc.) intensified, or visitor use dispersed or shifted completely to other areas.

REFERENCES

Carpenter, Philip L., et. al. Plants in the Landscape. W. H. Freeman Company, San Francisco, 1975.

Harris, Richard W. Arboriculture. Prentice-Hall, Inc. New Jersey, 1983.

Thompson, A. Robert. Tree Preservation Bulletins Nos. 1-9. National Park Service, Washington, D.C., 1940.

Shigo, Alex L. Tree Decay: An Expanded Concept. Information Bulletin Numbers 396 & 419, U.S. Department of Agriculture, 1979.

Zion, Robert L. Trees for Architecture and the Landscape. Van Nostrand Reinhold Company, New York, 1968.

PLANTING AND CULTURE OF SHRUBS AND GROUND COVERS

Shrubs and groundcovers provide numerous functions and form a vital part of the park landscape. When properly selected and maintained, they serve as focal points, accents, barriers and provide an aesthetic appearance which compliments and enhances the surrounding tree and floral displays. The landscape architect or designer and the grounds manager must have a thorough understanding of the cultural requirements of all plant material intended for use in the planting scheme. The plant's cultural requirements should match the existing or modified site conditions. This includes soil type, drainage, ph, availability or lack of moisture, exposure to heat, light, winds, snow and ice damage, and air pollution. In addition, the plant must serve the function intended in the landscape. The grounds manager should continually monitor the health and vigor of plants and take appropriate steps to correct any deficiencies which would cause plant stress and decline.

The successful management of plant material requires proper planting procedures and follow-up care. Prior to planting, perform a soil test to determine texture and ph. Follow-up with a test for soil drainage. This may be accomplished by digging a hole one foot deep, filling it with water and determining how long the water remains. If water is absorbed in less than two hours, the soil is adequate for planting. Otherwise, consider amending the soil, incorporating raised beds or providing downward or sideways drainage. Once this is complete, begin the planting project. The planting procedure involves determining when to plant, handling plant material, establishing the planting hole, fertilizing, planting, watering, pruning, mulching and follow-up inspection and care.

Know the specific cultural requirements of your established plant material and develop an annual maintenance program according to the plant's specific needs. This is particularly important if you have diverse plantings such as rhododendron and azalea, roses, juniper, formal hedge plantings, etc. Continue to keep abreast of current information in your field. Attend training classes, seminars, workshops and trade conferences on a regular basis. Communicate with other grounds managers and plant professionals from the National Capital Region Center for Urban Ecology (CUE) and the agricultural extension service. Refer to several books for specific information and subscribe to trade magazines in the field.

GENERAL PLANTING PROCEDURES

Planting Season: Spring and Fall are the preferable seasons to plant shrubs; however, Balled and Burlapped (B&B) and container grown stock may be planted whenever the soil can be worked and as long as adequate water is provided. Plant bareroot stock only in the spring and fall when it is dormant. Try to schedule spring and fall planting projects as early in the planting season as possible. This will enable the plants to become established in the ground prior to the onset of hot summer or cold winter weather. The fall planting season for B&B and container stock begins in late summer and for bare-rooted stock it begins as soon as the shrub's leaves begin to fall.

Handling Plant Material: Prior to planting, make certain plants are properly handled at all times. When handling B&B stock, carry the shrub with hands under the ball to help prevent cracking or breaking. A sack of burlap placed under the shrub could be used to handle and carry a heavy or bulky plant. When hauling or storing, protect the tops of the plants from high winds and high temperatures and prevent roots from drying, drowning and freezing.

Establishing the Planting Area: One of the major keys to transplant success and plant growth is a well-aerated single, textured-soil. This can be achieved in two ways, rototilling an entire shrub bed area prior to planting, or digging a wide hole for each plant. The wider the planting hole the better. This permits rapid root growth into the loosened, aerated soil. The majority of a plant's active root system has been found to be in the upper 12 inches of soil. Make certain to place the root ball on firm soil when planting at the proper depth. Plant at or above existing soil line. Shrubs should not be allowed to settle below the existing soil line.

Extreme caution should be used when attempting to alter soil texture. Contact the soil specialists from CUE whenever dealing with poor urban soils. In general, the goal is to have a soil with about five percent organic matter content. Organic amendments should not be incorporated into the planting hole of individual plants,

because more than one soil texture is created. There is potential for a majority of the plant roots being limited to the planting hole and few roots developing beyond the amended soil. In addition, there may be an effect on the soil/water relationship, which may cause an amended soil to become dry, while the surrounding soil is damp, or the amended soil would become saturated while the surrounding soil is still dry. Such developments would adversely affect plant growth, vigor, and ability to withstand stress.

Soil may be amended whenever a large shrub bed area needs improvement. Thoroughly mix the soil to create one soil texture. Clay soils which lack sufficient air or organic matter may be improved by adding coarse sand or organic matter. It is very important to mix clay with 1-2 mm coarse angular sand (a sandy-clay soil would require at least 80% sand by volume). Otherwise, there is the potential to create a concrete-like texture if fine sand, or sand with a wide range of particle sizes, or insufficient volume of sand, are inadvertently incorporated into the soil mix. Consequently, tilling in approximately five percent by volume of decomposed organic matter into the top 4-6 inches of soil surface is the preferred method to amend a clay soil. For example, to calculate tilling a 1,000 square foot area to a six inch depth, find the volume by multiplying 1,000 times the 0.5 foot (6 inches) depth. This equals a volume of 500 cubic feet. Five percent of 500 cubic feet is 25 cubic feet which is equivalent to approximately 1 cubic yard. Therefore, use 1 cubic yard of organic material per thousand square feet at a six-inch depth. Do not work a clay soil when it is wet.

Broadleaf evergreen species such as rhododendron and azalea require a well-drained highly-acid (ph 4.5 - 5.5) soil. Peat or leaf mold may be used as soil amendments to help acidify and release micronutrients into the soil. Raise the entire soil bed when soil drainage problems exist. If this is not possible, plant the individual shrub several inches high and gradually taper the soil from the top of the root ball down to the existing soil line.

Incorporate a dry controlled release fertilizer into the planting soil. The results from a soil analysis will help to determine the necessary amount of nutrients, sulphur or lime required to be added to the soil during planting time. Using organic or inorganic type fertilizer is a matter of personal preference, cost, and length of time needed for fertilizer release. Organic fertilizers such as cotton seed meal are used for acid-loving shrubs at the rate of 2-5 lbs per 100 square feet. When cotton seed meal is used, there is very little danger of burning or overstimulating plant growth. It also releases an acid residue as it decays.

A very light application of bone meal at a rate of 3-5 lb per 100 sq. ft. is used for shrubs which do not require an acid soil. Inorganic superphosphate (0-20-0) may be substituted for bone meal when only phosphorous is required. It releases more quickly than bone meal and costs less. Other types of inorganic controlled release fertilizers such as sulphur-coated urea, Osmocote, etc., may also be used. The initial costs of some of the inorganic controlled release fertilizers may discourage some managers from selecting such products. Consider using the 8-14 month long term slow-release fertilizer if follow-up fertilization cannot be accomplished due to heavy seasonal workload demands or unavailable personnel. The high material costs will be partially compensated for by a reduction in labor costs.

A thorough soaking of the planted area will allow the soil to settle, eliminate air pockets, and provide the necessary water requirements of the plant. Plant material should be properly watered until it becomes established. This will require knowing the soil texture and paying close attention to the soil moisture level surrounding the new shrub planting. In general, a new shrub planting requires frequent watering because the surrounding soil withdraws water from the root ball. When the surrounding soil is dry, a thorough soaking is required. However, when the surrounding soil is moist, frequent light waterings are necessary because the surrounding soil continues to withdraw water from the root ball. Continued excessive watering suffocates and kills plant roots and may eventually result in plant death.

Perform corrective pruning to balance the plant's shape and appearance, and remove damaged and cross-branches. Excessive pruning actually delays root growth by reducing the energy- producing leaf area of the plant.

Spread evenly a 2-3 inch layer of an organic mulch, such as leaf compost or shredded hardwood mulch, and make certain the mulch is kept away from the shrub stem. One only needs to look at nature where the ground litter of the forest floor acts as a natural mulch and is the very basis of forest life. In moderation, mulch provides numerous benefits to the plant and the soil. It conserves soil moisture, reduces soil compaction and erosion, improves soil structure, increases soil fertility as it decomposes to furnish humus, reduces weed competition, moderates soil temperatures and protects the shrub's feeding roots. Careful sanitary control measures should be utilized to alleviate encroaching invasive weeds into the storage mulch pile. An application of more than 3 inches of mulch will injure many plants by reducing soil aeration and keeping the soil too moist. In addition, excess mulching may increase the potential for rodent activity.

Once all the work is complete, remember to remove all ribbon, string and labels from the plants. Continue to inspect the new planting on a regular basis to correct any deficiencies and make certain it gets sufficient amounts of water, especially during the warm summer months. If plants are properly planted and maintained prior to their establishment, they will be easier to manage during their life time.

GENERAL PLANT MAINTENANCE AND CARE

The annual maintenance program for established plants depends on the expected level of maintenance, the type of plant material, the personnel available to perform the work, and available funding for supplies and materials. An understanding of the general concepts for managing established plants may help the grounds manager to be more flexible during periods when deferred maintenance cannot be avoided. Such a program should include watering, fertilizing, pruning, mulching, pest management, and winter protection.

Watering: Insufficient and excessive amounts of water will induce plant stress and may eventually cause severe decline or death. The grounds manager must, therefore, be familiar with the plant needs. This includes being aware of the soil texture, individual plant water requirements, size of plant, drainage problems, and microclimate conditions such as exposure to sun, heat or wind, the proximity of heat-absorbing objects like buildings or concrete surfaces, and competition with surrounding trees, shrubs, and groundcover. A general rule of thumb to estimate proper soil moisture content is to roll a small sample of soil into a ball, and if it crumbles when rubbed or squeezed, it probably has adequate moisture. If the soil can't be worked into a ball, the soil is too dry to provide sufficient water to plants. If the formed ball does not crumble when rubbed, the soil is too wet. Water thoroughly to at least a 4-6 inch depth and allow the soil to dry between waterings. This helps to improve soil structure and allows the roots to grow at their proper depth. Frequent light waterings of the top 1-2 inch soil layer encourages shallow rooting and weeds. This practice increases the chance for plant stress during dry periods and limits the soil area from which a plant can obtain nutrients.

Shallow rooting will also occur when soil is constantly waterlogged due to continued heavy watering. This restricts soil aeration. Although early morning is the preferred time to water, decisions are often influenced by available resources or visitor use activities. For example, the available water pressure (which is greatest in early morning) may affect the amount of area that can be watered. Visitor use activities may require watering turf before watering shrubs. Avoid wetting the foliage of roses, because they are susceptible to foliar disease.

Fertilizing: Several factors influence a fertilizer program; the results of the soil analysis, the size, age, and type of plant, and the plant' visual condition. The best time to fertilize is before or during the plant's period of active rapid growth in spring and/or when soil conditions enable fertilizer absorption in late fall. Do not fertilize deciduous shrubs until their leaves drop. Avoid late summer applications of nitrogen (no later than mid-July). This stimulates new top growth that will not have sufficient time to harden-off before winter.

The type and amount of fertilizer use varies according to plant species. In the absence of a soil test, use dry granular fertilizer with N-P-K ratios of 3-1-1 or 3-1-2. Organic mulches such as leaf compost also provide some nutrients. Utilize the specialized types of fertilizer made especially for acid-loving plants. There are controlled release fertilizers which are timed specifically to last for 3-4, 8-9, or 12-14 month periods. The fertilizer industry

provides a wide selection of fertilizers to suit each manager's fertilizer program. This includes various N-P-K analyses, organic and inorganic content, or whether they are controlled or quick release type. Use fertilizer according to the results of a soil analysis or follow the manufacturer's suggested application rate which in many instances is written on the bag of fertilizer. Scratch the fertilizer into the top inch of soil if there is no mulch or thoroughly soak the mulch to wash the fertilizer into the soil. Applying fertilizer just prior to a rain will help save labor and reduce water use.

Mulching: Maintain about a 2-3 inch layer of mulch throughout the year. This will provide the constant supply of humus that plants need. As organic mulches decompose, they release nutrients and increase soil fertility. Apply mulch in early spring to prevent soil moisture loss caused by early summer hot weather. Apply mulch in early winter to protect against plant roots from drying out as soil thaws and refreezes. Excessive mulching may retard proper soil aeration and cut off the necessary air to the plant's feeding roots.

Pruning: Pruning requires a full understanding and knowledge of the growth and flowering habits of various types of shrubs; that is, to know what, when, and how to prune. Shrubs are pruned for four principal reasons, namely, (1) to remove dead, diseased, or damaged wood; (2) to correct, rejuvenate or balance the shape of a plant; (3) to maintain or improve floral bloom; and (4) to shape them as design elements of an overall landscape design - i.e., as a formal hedge, focal accent, or topiary in an historic landscape.

Evergreens require minor pruning to remove dead and diseased branches or to remove spent blossoms before they go to seed. This allows shrubs such as rhododendron and mountain laurel to direct their energy to produce new shoots and flower buds for the following year's floral display. Avoid late summer and fall pruning because it will stimulate soft growth which may not harden-off before winter.

Shrubs are pruned according to the location of new shoot or limb development. Shrubs such as clethra, lilac, witch hazel, and viburnum do not regularly produce vigorous growths from the base or lower branches of the plant. Most of the growth occurs on the outer end of the older branches. Prune the first several years after planting to provide a framework of main branches. Minimal pruning is required once these plants become established. Some shrubs such as the red and yellow stem dogwood are valued for their attractive winter stem display. Each year prune the older stems very low to the ground in early spring.

Shrubs are also pruned according to their season of flowering, that is, those that flower on old wood and those that flower on new wood. In general, prune shrubs that flower before July immediately after they bloom. The floral display occurs from 'old wood' which developed the year before. Shrubs in this group include forsythia, azalea, viburnum, early flowering spirea, mock orange, etc. Shrubs that flower after July generally develop buds during the spring on 'new wood' or wood of the current season's growth. Prune these shrubs during winter or early spring as this will allow for a maximum amount of time for the flowering wood to develop. Shrubs in this group include clethra, kerria, late flowering spirea, hydrangea, etc. Roses are pruned more often than other shrubs. Refer to the many books which specialize in their culture and care.
Note: Many shrubs should not be pruned or do not require regular pruning, unless they are to be maintained as formal hedges. For example, do not prune any shrub in a shape (ball, cone, etc.) unless it is in a formal garden and an integral part of the design. When in doubt, the best rule is not to prune. More shrubs have been ruined by pruning than lack of it.

Pest Control: A successful pest control program requires knowledge of the causes and symptoms which affect plant stress. This includes disease, insect, and weed infestation, environmental influences such as air pollution, chemical injury, mechanical damage, drought, heat, cold, poor soil conditions, nutrient deficiency, etc. Continued exposure to environmental stress increases plant disease susceptibility and attack by insects. Refer to "The Guide for Pesticide Use in the National Park System" issued by the Biological Resources Division at WASO.

Develop a program to monitor plants every two weeks from April through September. Record all observations concerning the times of diseases and pests, as well as soil, temperature, and moisture conditions. Review

previous years' data to see whether a specific problem occurs in any type of predictable pattern. Once a problem has been diagnosed, consult with the park pesticide coordinator and follow the park-approved control measures for managing the pest. Make sure maintenance personnel thoroughly carry out the action plan according to your specifications.

Winter Protection: Generally a combination of several factors cause winter injury to plants. This includes the plant's condition, weather influences, site factors and maintenance practices. The plant condition depends on plant health, genetic cold tolerance, and whether the plant has properly acclimated to cold winter weather. Drought, low temperatures, high winds, snow cover, bright sunshine, unavailable moisture caused by frozen ground, and warm temperatures followed by very low temperatures are examples of weather influences which induce winter injury. Inspect the area to see if any site conditions exist which may result in plant injury. Look for soil drainage problems or exposure to high winds. Improper or deferred maintenance practices could also cause winter injury. Excessive or late fertilizer application induces soft vegetative growth which will not harden off before winter. Over mulching reduces aeration and encourages root formation in the mulch layer. This exposes the plant to root-killing injuries. Insufficient watering during summer and late fall does not provide the necessary water that plants require to prepare for severe winter weather conditions.

There are several measures which the grounds manager may take to reduce winter injury to plants. Correct soil drainage problems, or relocate plants. Water the plants as needed throughout the summer and fall. Deep soak the roots of shrubs at least once a week between mid-October and mid-December. Spray antitranspirants on young plants and those sensitive to wind-burn damage. Fertilize evergreens with a controlled release fertilizer after the first killing frost. Add mulch if needed or loosen it to increase its insulation capabilities. If injury has occurred, delay corrective action until spring. It is much easier to determine the actual extent of damage when new growth begins. Lightly fertilize and water thoroughly during the following summer.

GROUNDCOVERS

Most groundcovers are woody plants or perennials, however, annuals and grasses are also utilized. Groundcovers help to enhance and complement the visual character and scale of the landscape scene. They define space, provide texture, form, and color contrast and are used to correct landscape problems such as soil erosion, wet and dry areas, difficult mowing areas, etc.

Correct soil ph, if needed, and complete the required soil preparation work. Weeds will be a major problem until the planting is fully filled in and the ground is covered. Weeding is extremely labor intensive and plant roots can be severely damaged by hoeing or pulling weeds. Such activity increases plant stress, hinders plant growth and vigor, and does not kill established perennial weeds. If appropriate and permissible, consider soil sterilization or a pre-emergent herbicide prior to and during the establishment period. Early spring planting is preferred because the plants will have a longer time to get established before winter. Fertilize lightly, add mulch and water as needed. Use biodegradable mesh to stabilize steep banks. Space plants according to the type of plant, size, and how quickly it will spread.

Once fully established, most groundcovers will require some maintenance. Immediately replace dead plant material, and prune dead branches. It may be necessary to remove leaves and apply antitranspirants. Periodically check soil ph, water as needed, and on occasion apply an organic fertilizer.

REFERENCES

Boddy, Frederick A. Groundcover and Other Ways to Weed-Free Gardens. Douglas Davis & Charles Limited, West Vancouver BC, 1974.

Brickel C., *et al.* The Encyclopedia of Gardening Techniques. Exeter Books, New York, 1984.

Brown, George E. The Pruning of Trees, Shrubs, and Conifers. Winchester Press, New York, 1972.

Bush-Brown, James. America's Garden Book. Charles Scribner's Sons, New York, 1980.

Fialka, Deborah R. The Washington Star Garden Book. The Washington Book Trading Co., Arlington, VA. 1988.

Harris, R.W. Arboriculture, Care of Trees, Shrubs, and Vines in the Landscape. Prentice-Hall Inc., New Jersey, 1983.

Hudak, Joseph. Shrubs in the Landscape. McGraw-Hill Book Co., New York, 1984.

Johnson, W.T. and H.H. Lyon. Insects That Feed on Trees and Shrubs, an Illustrated Practical Guide. Cornell University Press, Ithaca, New York, 1976.

Phillips, C.E. Lucas and Barber, Peter N. Ornamental Shrubs. Van Nostrand Reinhold Co., New York, 1981.

Reddell, Rayford Clayton. Growing Good Roses. Harper & Row, New York, 1988.

Whitcomb, Carl E. Establishment and Maintenance of Landscape Plants. Lacebark Publications, Stillwater, Oklahoma, 1987.

Wyman, Donald Ground Cover Plants. MacMillan Co., New York, 1966.

Wyman, Donald Shrubs and Vines for American Gardens. MacMillan Co., New York, 1969.

Wyman, Donald Trees for American Gardens. MacMillan Co., New York, 1965.

Wyman, Donald Wyman's Gardening Encylopedia. MacMillan Co., New York, 1971.

Contact your local cooperative extension service to receive current bulletins and pest control recommendations. In National Capital Region, contact the Center for Urban Ecology (CUE). Also, coordinate with your park Integrated Pest Management Coordinator.

Floral displays are a focal point in many NPS landscapes or are added to enhance existing landscape features. Three seasons have traditionally been represented in these displays; bulbs in spring, annuals during summer and chrysanthemums during fall.

BED PLANNING AND PREPARATION

When ordering plant materials for existing floral display beds, it is important to consider each plant's cultural requirements and whether you can provide them. Does the plant need sun or partial shade? Does the bed have good fertility and good drainage? Does the plant require frequent watering and, if so, is water readily available? Addressing these questions initially will save maintenance time later on.

Many newer varieties have been bred for certain characteristics such as pest-resistance, heat-tolerance, and disease-resistance. These may be particularly suited to your situation.

Because annuals and chrysanthemums are purchased by contract, they should be periodically inspected during production at the grower's location. Whoever is designated at the park level as contracting officer's representative (COTR) for these contracts should be making inspections. The grower is responsible for producing quality plant material, but a few checks with them during production will ensure getting healthy, vigorous materials of the correct size. Also, if the plants have had any disease or insect problems during production, you will be alerted and can watch for possible reoccurrences. When plant materials are delivered, each plant/flat should be checked for pests, disease, uniformity and vigor. Plants should not be accepted if they don't meet these qualifications. Your maintenance time will be significantly increased if inferior quality plants are accepted. If plants have been inspected throughout the production period, there will be no surprises at delivery time.

Color is an important factor when selecting plant materials. Floral displays are intended to make an immediate, eye-catching impression on the viewer. This can be accomplished easily by the use of one or two bright, bold colors in a massed planting. By limiting the number of colors to one or two complementary or strongly contrasting colors a strong visual impression will be made. Or use two contrasting colors, such as red or orange for the center or back of a bed, with a lower plant with white or yellow flowers as a border. Use of three or more colors can create a "busy", or even a washed-out effect, unless a mixture of colors of the same kind of plant are used instead of single colors, i.e., Marigold Jubilee Mixture.

When selecting seasonal plant material for floral displays, its necessary to consider the bloom color of surrounding or adjacent permanent plant material which would be in bloom at the same time. For example, if a display bed is next to a planting of azaleas, remember they could be in bloom at the same time as a tulip display. So be sure these colors are also complementary or contrasting colors. If you have questions regarding appropriate color combinations, check with the Regional Landscape Architect or Horticulturist.

Generally the steps for bed preparation are as follows:

1. Add fertilizer (according to soil test results),
2. Rototill,
3. Grade bed,
4. Mark bed for plant spacing,
5. Set plants on marks,
6. Plant.

It's a good practice to have a periodic soil test done for each of the floral display beds. See Chapter Six for further information. Soil testing will enable you to add precise amounts of fertilizer and lime to each bed as needed.

A commonly used technique is to sterilize soil in floral display beds annually with methyl bromide. This procedure prevents existing weed seed from germinating and kills existing weeds and nematodes; it is effective for approximately one year. Timing for this operation can be tricky if you plan to do this in the spring between the tulip display and planting of annuals. It may be impossible to do in spring, if there are late spring rains and/or you have planted any of the late-flowering spring bulbs like the Darwin or Cottage tulips. Another timing factor to consider is that once applied, the beds must be kept covered for at least 24 hours, and then uncovered for a minimum of 48 hours prior to planting, in order for all the gas to disperse from the soil.

Methyl bromide is a restricted-use pesticide. The park must request and receive approval before use of this or any pesticide. See Chapter Twelve for more information.

Be aware that most Salvia varieties are sensitive to methyl bromide treated soil and should not be planted in recently treated beds.

After rototilling the bed, it is important to keep to a minimum the number of people who walk back through the bed to avoid compacting the soil. Grading the bed should be done so the soil surface is level in all parts of the bed. If the surface is uneven, the high spots will dry out more rapidly and the low spots will receive more water. This will cause uneven growth. The plants in low spots will also be more susceptible to root rot, phytophthora and other diseases if left in standing water.

Marking the bed should be done with a string line and a bed marker. A bed marker consists of a wooden bar with 2 or 3 perpendicular wooden dibbles descending from it. These dibbles may be adjusted to allow varying spacing of plants. This is easiest way to ensure straight rows and equally spaced plants. With the use of these two tools, the visual quality of floral displays is noticeably improved.

ANNUALS

Annuals are plants which complete their life cycle within one year. This group of plants is the main-stay of all our floral displays. Some of the plants we class as annuals are not actually true annuals, but are used as such in floral display beds; for example, the several genera of dusty miller.

Annuals are the most commonly used bedding plant materials and are valued for their long season of bloom, varied color and form, and relatively easy culture. Annuals generally thrive in full sun, and need plenty of water and regular fertilization. If cost is not a deterrent, buying larger bedding plant materials can be very beneficial. Larger plants have a more extensive root system which makes transplanting easier and survival rates higher. But more importantly, larger plants should give a longer season of bloom because they are mature, more developed plants.

Spacing of annuals varies from plant to plant depending on the plant's ultimate size. Seed catalogs have spacing information, but if you're unsure check with the Regional Horticulturist or Landscape Architect.

When transplanting annuals from container to display bed, gently knock the plant from the pot, place in the hole and add soil, making sure the top of the root ball is even with the soil level in the bed. Then cover the root ball with a layer of soil and gently tamp down. If plants are planted too high, this will leave roots exposed and subject to drought stress. If annuals have become severely pot-bound, score the root system gently several times before transplanting. This will promote new root growth and enable the plant to more rapidly translocate water and nutrients. Annuals require more frequent watering than perennials because they are comparatively shallow-rooted. If plants are under stress from drought, they will not produce vigorous growth and bloom. Avoid

allowing a hard crust to form on the top of the soil. Frequent shallow cultivation allows water to penetrate the soil and reach the root system.

Removing faded blooms or dead-heading is another technique which promotes better floral display and a longer season of bloom. This prevents the flowers from going to seed and saves plant "energy" to be used in new growth. Typically, dead-heading is performed on geraniums once a week. All annuals will benefit from this practice.

Annuals are vigorous feeders. Combining foliar feeding with a top-dressing application of granular fertilizer produces best results. Foliar feeding is usually done on a two week cycle with a water-soluble evenly-balanced fertilizer. A low analysis granular fertilizer should be applied and incorporated into soil at time of initial planting and repeated at the beginning of July and the beginning of August, according to manufacturer's recommendations.

BULBS

Spring-flowering bulbs create spectacular displays of color. Tulips are the most commonly used spring-flowering bulbs for massed plantings. Tulips are categorized by season of bloom: Early, Mid-Season, and Late. The following types of tulips have been listed in approximate order of bloom:

Early Tulips

- Kaufmanniana Tulips - These are very short early-flowering tulips. Also called waterlily tulips.

- Fosteriana Tulips - These are early tulips of medium height, which includes the Red Emperor variety.

- Darwin Hybrid Tulip - This group of medium-tall tulips are strong, vigorous growers with large blooms; they are excellent for large massed displays.

Mid-Season Tulips

- Single Early Tulips - Medium height tulips also used for bedding. Some varieties are particularly fragrant.

- Double Early Tulips - These as a group are somewhat shorter than the single early varieties but are large, double-flowered and strong-stemmed.

- Triumph Tulips - Heights range from medium to tall; most are very robust and strong-stemmed. These tulips have a wide range of color and are good choice for mass plantings.

Late Tulips

- Double Peony Tulips - This group of tulips has large double-flowered blooms borne on tall stems. Flowers somewhat resemble peonies.

- Lily-Flowered Tulips - These tulips have a distinctive, beautiful form with pointed, mildly-reflexed petals. They are tall growers, though somewhat weak-stemmed; often are damaged by heavy spring storms.

- Darwin Type Tulips - These are the classic tulip form. There is great diversity in color with these tulips. They are quite tall, have large, long lasting blooms and are among the last tulips to flower.

There are other tulip types, but none are recommended for large floral displays. Among them are: Parrot Tulips, Fringed Tulips, Green Tulips, Greigii Hybrid Tulips, Species or Botanical Tulips, and Multiflowering or Bunch Tulips. These tulips generally are used as small groupings, in cut flower gardens or in perennial borders in residential settings, such as historic houses, or in floral library displays.

For uniform vigorous, growth and bloom, tulips need to be treated as an annual and replanted each year. Tulips should be planted during late fall, from early to mid-November. Bone meal should be tilled into the soil during bed preparation. Tulips should be planted pointed end up, this may seem obvious to those who have done it before, but many new gardeners are not aware of this fact. The bulbs should be set six inches deep and eight inches apart. After planting, little maintenance is required in tulip beds. Though in spring after tulips are up three to four inches, a shallow, gentle cultivation will remove the hard soil crust and ease water penetration.

Two other types of bulbs are used to a lesser degree in spring- flowering displays. Grape hyacinths are small bulbs often used as a border in tulip beds. They should be planted four to five inches deep and three inches apart. Hyacinths used alone or interplanted with early flowering tulips make an interesting and fragrant display. They should be planted about the same depth as tulips, six inches and six to eight inches apart. Both hyacinths and grape hyacinths benefit from the addition of bone meal to the soil.

Narcissus or daffodils are commonly used as a mass perennial planting, though not as a part of a seasonal floral display bed. They are most often naturalized in groups of at least 25-50 in woods edges, groundcover beds or grass areas or underplanted in perennial beds. Narcissus should be planted before tulips in early to mid October. In order for them to bloom well the first year, it is necessary that they produce roots before a hard frost. Depth of planting and spacing depends on the size of the bulb. A rule of thumb is plant the bulb twice as deep as its height. The smaller varieties should be spaced three to four inches apart; the larger varieties six to eight inches apart. Narcissus also benefit from the addition of bone meal to the soil at the time of planting. After bloom the foliage should be allowed to cure or die back naturally before it is pulled off or cut. If removed while still green, the vigor of the bulb will be severely diminished, resulting in poor flowering the following year. This is important, since Narcissus are perennial and not replanted each year.

CHRYSANTHEMUMS

Chrysanthemums (mums) are the last plant material used in the floral display bed each year. Their season of bloom is dependent upon the timing of the first hard frost. Mums used in floral displays should be garden-hardy varieties that have been field grown. Due to high cost, many parks are eliminating mums as part of their floral displays, leaving annuals in the beds through September. However, mums give color and texture in the fall that no other plant can provide.

Mums should be planted from mid September to the beginning of October. After planting they should be thoroughly watered in. Because of the short display time, no special culture is needed except for occasional, shallow cultivation and watering when dry.

PLANT SPACING

SPACING	NO. OF PLANTS / SQ.FT.
4" O.C.	9.1
6" O.C.	4.0
8" O.C.	2.25
9" O.C.	1.78
10" O.C.	1.44
12" O.C.	1.0
15" O.C.	0.64
18" O.C.	0.444
24" O.C.	0.25
30" O.C.	0.16
36" O.C.	0.11
48" O.C.	0.062

PESTICIDE POLICY AND INTEGRATED PEST MANAGEMENT IN NCR

Within the National Parks populations of native insects and pathogens existing under natural conditions are natural elements of the ecosystem (1). Accordingly, populations of native insects and the incidence of native diseases will be allowed to function unimpeded except where management is required to (a) prevent the loss of host or host dependent species from the ecosystem; (b) to prevent outbreaks of the insect or disease from spreading to forests, trees, and other vegetative communities, (c) to conserve threatened or endangered animal populations outside the area, (d) to conserve and protect flora and fauna in developed zones and (e) for reasons of public health and safety (Reference: Natural Resource Management Guidelines, NPS-77, Chapter 2 Integrated Pest Management).

Previously, "conventional or calendar based" pest management practices were used to treat pests. In conventional pest management, chemical pesticides were applied on a regular basis dictated by the calendar. Pesticides were applied as preventive measures whether or not they were needed. Pest organisms were treated when their damage was apparently obvious. Often the manager was treating the damaged resource rather than the pest which had already come and gone. This is known as "revenge treatment". If, by chance, the pests were present, the conventional method of pest management subdued pest populations for short periods of time, at best. This occurred because the manager usually applied the pesticide when the damage was obvious and in most pest populations, the damage is noticed near the end of the pest's cycle. The pest is frequently entering a stage of dormancy (egg, pupae, cyst, spore, natural death) when the pesticide is applied. Pesticides are frequently not effective in this stage. This cycle continued. The pest reappears, damages the resource...carries out its life cycle...eventually the manager notices the damage and again a pesticide is applied, too late.

Pests become resistant to pesticides which are used routinely. Routine use of the same pesticide kills susceptible individuals within a population, simultaneously, it leaves the resistant individuals to reproduce "pesticide resistant" offspring in the following generations. Also, secondary pest outbreaks result due to constant pesticide use destroying resident populations of beneficial insects (parasites/ predators).

In conventional pest management the manager did not keep written records of pest activity in relation to resources damaged, time of year, or weather patterns. No post treatment assessment was recorded to evaluate the management efforts. Pest management was in a "see and spray" vicious cycle. In 1979, the NCR began the transition to a more sound pest management program: Integrated Pest Management or IPM.

Currently, Natural Resource Management Guidelines (NPS-77, Chapter 2, Integrated Pest Management) requires that Integrated Pest Management (IPM) be applied wherever practicable.

INTEGRATED PEST MANAGEMENT

IPM is a decision making process that determines IF you need pest suppression, WHEN you need it, WHERE you need it, and WHAT strategies or tactics to use.

The first step in starting an IPM program is to identify the pest organism, learn about its biology, then proceed with management strategies.

In IPM, pest populations are MONITORED on a regular basis. Monitoring is the key element in a successful IPM program. Managers must realize that they can accept a certain pest population level in the ecosystem. The manager should take a realistic approach and concentrate on managing the pest population at tolerable levels.

In an IPM program, the manager examines the resource, quantitatively records the number of insects/damage/diseased areas, then makes a decision for management action. Cultural, mechanical, resistant varieties, biological and chemical management strategies are investigated first. If the decision is made to incorporate chemical pesticides into the management plan, the least toxic, most target specific pesticide is

selected and applied when the pest is most susceptible. In IPM all management tactics are appropriately timed with pest biology.

Through regular monitoring the manager is always aware of the pest's life cycle and its population level. He/she knows when the population is building to the damaging level or the injury level.

Injury Level: It is the manager's responsibility to establish injury levels for each pest problem (insect, weed, or pathogen). Each manager may establish their own injury level depending on the site, how intensively it is managed, and the role the particular resource plays in the site. The injury level is the maximum number of individual pests or the maximum number of damaged leaves that can be tolerated. The goal is to keep pest populations below the injury level. Management actions should be taken just before the pest population reaches the injury level. This is called the action threshold.

Action Threshold: The action threshold is the pest population level or the damage level at which management actions should be introduced to prevent the pest population from exceeding the injury level (causing unacceptable aesthetic or economic damage). Thresholds may be flexible depending on the site, role of the resource, and long term management goals.

Request for Pesticide Use: Certain pest management strategies may require the use of a pesticide. A pesticide is defined as any agent used to destroy pests. Each chemical pesticide registered with the EPA has an individual registration number on the pesticide label.

PESTICIDE REVIEW PROCESS

All pesticide use as well as the use of biological control agents such as parasitic wasps must be reviewed and approved by the Park IPM Coordinator, the Regional IPM Coordinator and finally the Servicewide IPM Coordinator prior to use on an annual basis. This three tiered level of review can be carried out by phone within minutes in an emergency situation. The common procedure is for a written 1021-a form, Request for Pesticide Use, to be submitted to the Regional IPM Coordinator, prior to pesticide use by your Park Coordinator. All phone approvals must be followed up with the written form 1021-a (Appendix A, form 1021-a and directions). Requests for restricted use pesticides, pesticides which may get into aquatic systems, pesticides that can be expected to affect threatened or endangered animal or plant species and pesticides for application on 2,560 acres, require Departmental Review (Appendix B, Departmental Review form and directions).

In addition, NPS pesticide applicators must log in all pesticide use on a daily use log (Appendix C, log and directions). Facts such as pesticide name, location of treatment, amount applied are recorded for future reference. This log is also required by the Division of Pesticide Regulations for Maryland, the District of Columbia and Virginia. Inspectors from state agencies are free to observe your licensed pesticide applicators and inspect your facility for these records at any time.

All pesticide use must be under the direct supervision of a Licensed Pesticide Applicator. Records documenting the critical timing of insect emergence, and/or pesticide use concerning site renovation should be kept in an active folder specific for the site or resource. This documentation will provide a history of the pest, pesticide applications, structural modifications or repairs and should be easily accessible to NPS employees or other specialists assigned to the site for future reference.

The NCR IPM Coordinator and staff are located at the Division of Professional Services, Center for Urban Ecology (CUE). CUE is an important resource available to all Regional employees and can provide information and assistance in the area of pest management, soils, urban wildlife, horticulture, water resources, and ecology (Appendix- D, staff listing for CUE).

The Servicewide IPM Coordinator and staff are located in the Servicewide Office, Division of Wildlife and Vegetation (WASO 343-8115). The Division has prepared an IPM Information Manual with packets on commonly encountered pests of the National Park Service. These packets contain established thresholds and management techniques for the Manager. A series of video tapes are also available through the Regional IPM Coordinator for use in park training programs (Appendix- E, list of IPM Information Manuals and Appendix-F, training videos presently available).

PEST MANAGEMENT IN TURFGRASS

Insects: A reasonably healthy, moderate to low maintenance lawn should be able to support a sizeable insect population and even benefit by the activities of some. Earthworms are renowned for their soil mixing, aeration, and granulation and except on a putting green, should be encouraged. Even grubs will have a positive aerating effect as they move up and down in the soil. The root pruning done by a moderate number of grubs is serious only in dry years.

The first step in turf pest management is pest identification. If a pest is suspected, samples should be taken and identified. If you are unable to identify the pest, refer to the IPM Information Manual first, then to the Management Agronomist or IPM Coordinator for assistance. Local extension agents and universities are also helpful in identifying pest organisms. Once identified, review the pest's biology to increase your knowledge of the pest. The more information you learn about the pest, the more intelligent your management decisions will be.

After identifying the pest, it is necessary to establish a random monitoring technique and a standard sampling size which will enable you to assess the pest population size.

> EXAMPLE. Imagine that its late August, you notice that an area of class A area turf is browning in spots. After poking around in the soil just below the turf, you find white grubs around the turf roots. The Management Agronomist identifies them as japanese beetle grubs. Your task is to read information on this insect's life cycle and habits in the IPM Information Manual. After reading you learn that by late September the grubs move down 8 inches into the soil for the winter, then move back up just below the surface in late March to resume feeding on turf roots.
>
> Before considering how to manage the grubs, you must know what level of infestation you have. This involves random monitoring and recording quantitatively how many individual grubs are present in a known area of turf. The sample size could be, for instance, a randomly selected square foot of turf. Monitoring could be accomplished by tossing a brightly painted rock over your shoulder, walking over to where the rock has landed and with a knife, neatly removing a square foot of turf from the lawn. This square can be replaced after monitoring. Inspect the square, count the number of grubs in the one square foot of turf and record the count on a monitoring sheet. Rate the visual quality of the turf in that sampling area. Do this several times to establish an action threshold (the grub level per square foot at which damage cannot be tolerated).
>
> For example: you might rate areas with 5 grubs per square foot as "good" aesthetically speaking; areas with 8 grubs per square foot as "borderline acceptable"; areas with 9 grubs per square foot as totally "unacceptable". Your action threshold would then be 8 grubs per square foot. Repeat this sampling procedure until you have several counts. Your action threshold will vary during different seasons. During the summer when turf is under moisture stress, it is more susceptible to grub feeding than the actively growing spring turf. Consequently, threshold counts may be higher in the spring, when the actively growing turf can withstand and recover from the grub feeding.

The established threshold of 8 grubs per square foot will determine exactly where you will take management action. There are no cultural or mechanical control measures available for japanese beetle grubs and the more resistant turf species have undesirable characteristics; therefore, these are eliminated as potential control measures. Chemical (insecticide) and biological (milky spore disease) controls are available.

The desirable attributes of milky spore are its specificity (it only affects japanese beetle grubs) and only one treatment is needed. However, it is relatively expensive and effective control won't be realized for 2 or 3 years. The effect from an insecticide will be more rapid, but less lasting and because insecticides are not specific, desirable insects will be harmed. There is also the possibility of toxicity to wild life and persistence of traces in the soil.

Since an insecticide treatment now will not help the grass this fall, you treat now with milky spore, monitor again in the spring (after grubs have returned to the surface), and use spot treatments with an insecticide on those areas where the grub population meets the threshold level.

Monitoring should be conducted in the spring to assess the present population and determine if management action is necessary. If thresholds are reached conduct spot treatment then monitor again, post treatment, to determine how effective the treatment was. Record your results and compare them to the previous monitoring results. Monitoring, if conducted on a regular basis (twice yearly in this case) would keep the site manager abreast of approaching pest populations before the resource is damaged. Pre-crisis monitoring will allow the manager to suppress the pest population before it exceeds the threshold and the resource exhibits damage.

Weeds: A good weed management program is based on the premise that a healthy vigorous turf is most resistant to weed invasion. This means that cultural practices (fertilizer, lime, irrigation, mowing, species selection, etc.) must all be conducive to healthy vigorous turf. A healthy turf will out compete most weeds.

During renovation or when weed populations exceed the acceptable threshold that has been set by the site manager, it may be necessary to integrate temporary weed suppression into the management program. If the site manager is unsatisfied with the turf appearance he/she should follow these guidelines: review the past management of the turf note how much and when fertilizer and water was applied, if and when overseeding was done, review of recent weather patterns will also be helpful. The site manager should then randomly monitor the turf to determine what weeds are present, where they are and how much of the turf is affected. The next step is to establish an action threshold level, or how many weeds can be tolerated. This is determined by the site manager through monitoring. Factors such as significance, and class of the resource and historic background concerning site upkeep should all be taken into consideration when establishing a threshold.

A number of effective herbicides are available for pre-emergence control of annual grassy weeds. All are about equally effective for control of crabgrass (*Digitaria* spp.). Oxadiazon is more effective against goosegrass (*Elusine indica*), but is more likely to injure the desirable grass than the other herbicides. Siduron is the most specific for crabgrass seedlings and can be used with a spring seeding. It is, however, one of the less long lasting. DCPA is one of the longer lasting and has some effect on dandelion seedlings, but not established plants. A late spring application of DCPA could interfere with early fall overseeding. Other preemergence herbicides include benefin, bensulide, trifluralin and combination products. Short residual can be partially overcome by a second half-rate application in midseason. The final selection will probably be based more on cost and availability than on differences among the herbicides.

Perennial grassy weeds are more difficult to manage. Chlorsulfuron (Lesco TFC) has recently been labeled for "spot treatment...to manage perennial bunch or clump grasses such as tall fescue in Kentucky bluegrass, fine

fescue, bentgrass mowed over 1/2" in height, bahiagrass, and bermudagrass lawns." There is no other selective control for perennial grasses. The only approach is non-selective, kill everything, and reestablish the desired species. A degree of selectivity can be achieved by limiting the application of the non-selective herbicide to the weed grass, and repairing the spot with the desired species. Round-up (glyphosate) is a readily available herbicide for this use.

Selective management of broad-leaved weeds has traditionally been the role of the phenoxy compounds, especially 2,4-D, 2,4,5-T and related compounds. Misuse of 2,4,5-T by the military in Vietnam led to problems which resulted in it and 2,45-TP being taken off the market. A survey in Nebraska which linked one form of cancer to farmers who had used 2,4-D has led to a decline in the use of 2,4-D and intensified the search for substitutes. MCPA and 2,4-DP (dichlorprop) are used in herbicide mixtures as substitutes for 2,4-D. Triclopyr has been used instead of 2,4,5-T or 2,4,5-TP.

MCPA and 2,4-DP are effective on fewer weed species than 2,4-D but the chronic effects are not as well known and could even be worse. Because of the more limited spectrum of species controlled, these are almost always used in a mixture with MCPP or dicamba or both.

The weed population can frequently give an indication of the health of the turf or soil. Knotweed and goosegrass are survivors on compact hard soil. Crabgrass thrives on cutting heights too low for most lawn grasses, and where light frequent watering is practiced. Clover is more conspicuous in nitrogen-deficient turf. Annual bluegrass seems to prefer excessive phosphorus. Nutsedge does best at water levels higher than required for healthy turf.(See Appendix G, Draft Guidelines for Management of Weeds in Turfgrass 11/10/89).

Diseases: As with weeds and insects, a healthy, well maintained turf of the proper grass species is the first line of offense in disease control. Of the approximately 20 diseases that have been identified as affecting turfgrasses, only a few are likely to be serious on a specific lawn, and the severity will be significantly reduced with good management.

Grasses vary greatly in their susceptibility and resistance to disease. In selecting a grass for a particular site, a prime consideration must be its suitability for the use and environment of the site. Powdery mildew is not a concern in a lawn in full sun, but in shade it can be a serious problem and resistant varieties should be selected. Conversely, the fusarium blight syndrome is most severe in full sun on south facing slopes.

No one variety is resistant to every disease. Blends are used to broaden the genetic base, so that part of the population will be resistant to different disease, and to provide some physical separation between plants of the same variety. A blend of Kentucky bluegrasses for a typical lawn would include a variety resistant to the old helminthosporium syndrome, one resistant to the fusarium blight syndrome and one resistant to either stripped smut or powdery mildew, depending on the shade.

The same principle applies to a ryegrass blend. Most improved perennial ryegrasses are susceptible to rust; only a few are tolerant of heat. Therefore, the blend should include a variety that is more resistant to rust, one tolerant of heart and at least one other variety; one resistant to pythium or one resistant to the red thread diseases.

Unfortunately, there are fewer differences among the tall fescues; some are thought to be more shade tolerant than others, but all are susceptible to brown patch. Nevertheless, they should still be planted in a blend to seek a genetic diversity which might help when a pestilence unknown at this time strikes.

Other things being equal, a grass plant mowed at 2" will be healthier and more able to resist infection than one mowed at 1". A dull mower leaves a ragged edge which allows easier entry of the pathogen. Excessive clippings,

those resulting from delayed mowing or from over-fertilization, which tend to mat can encourage the disease-inciting fungi. Normal clippings which result from timely mowing of a properly fertilized lawn are beneficial.

Excess water is an invitation to disease. Irrigation water should be limited to what is needed for survival of the grass; it should be timed so that the leaves and surface are wet the minimum amount of time. Frequent light watering, especially in the evening, encourages diseases and weeds; and must be avoided.

Moisture and temperature problems can be intensified by surrounding a lawn with trees, shrubs or other plantings, or by walls which impede air movement across the turf. If warm, moist, stagnant air is suspected of contributing to disease or insect problems consult with an agronomist and a landscape architect to confirm the suspicion and to jointly devise a solution which will relieve the condition and still maintain the design integrity of the area.

Early spring fertilization produces excessive succulent growth of cool season grasses. This depletes the root reserves of carbohydrates, results in too many clippings to decompose harmlessly and yields a plant which is easy for the fungus to enter.

Fungicides should be avoided on lawn turf, if at all possible, since in this situation they tend to cause more problems than they solve. Fungicides are non-selective; they kill the beneficial, as well as the pathogenic, fungi. Soil borne fungi decompose thatch and clippings, convert non-nitrate nitrogen to nitrate which the grass uses, break pesticides down into harmless compounds and protect the turf by virtue of their antibiotic properties. If fungicides are used there is a tendency to become dependent on them.

Site managers should observe and record weather patterns as fungi require high moisture levels. Management actions should be altered accordingly.

REFERENCES

Olkowski, William and Helga Olkowski. 1983. Integrated Pest Management for Park Managers: A Training Manual. National Park Service pp. 90

Sherald, James L. and Carol L.J. DiSalvo. 1987. Integrated Pest Management in the National Capital Region of the National Park Service. Journal of Arboriculture. 13: 229 - 235.

National Park Service Integrated Pest Management Information Packages. Biological Resources Division, National Park Service, Washington, D.C. 1984.

National Park Service, Natural Resource Management Guidelines, NPS-77. "Integrated Pest Management", Chapter 2.

FORM 10-21A
(REV. 11/83)

UNITED STATES DEPARTMENT OF INTERIOR
NATIONAL PARK SERVICE
PEST CONTROL PROGRAM REPORT

TARGET PEST:

PRODUCT NAME:

EPA REG. #:

ACTIVE INGREDIENT:

% or #/G (/)
ACTIVE INGREDIENT:

MIX OF PRODUCT
WITH DILUENT:

PRODUCT USAGE RATE:

PRODUCT AMOUNT USED
PER APPLICATION:

METHOD OF TREATMENT:

FORM APPLIED:

AREA OR UNITS TO
BE TREATED:

NUMBER OF SITES:

DESCRIPTION OF SITES:

NO. OF APPLICATIONS :

REGION:

YEAR:
ORGANIZATION:
PROJECT:
(e.g., YELL-84-01)

PURPOSE:

SEASON OR PERIOD
OF APPLICATION:

AREAS TO BE AVOIDED:

AREAS TO BE TREATED
WITH CAUTION:

PRECAUTIONS:

USE OF TRAINED OR
CERTIFIED PERSONNEL:

MONITORING:

PERSON TO CONTACT:

OTHER REMARKS:

SIGNATURES OF APPROVAL

PARK:_____ DATE:____

REGION:_____ DATE:____

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NATURAL RESOURCE MANAGEMENT
NPS-77
Natural Resource Management

GUIDELINE
Chapter 2
Exhibit 1

Integrated Pest Management

REPORT FORMS AND INSTRUCTIONS

A. Pest Control Program Report (Form 10-21A)

All requests for pesticide usage require the submission of a Form 10-21A. Each item must be completed in accordance with the following instructions. A new Form 10-21A must be submitted for each project annually, even if the project had been approved in previous years. A blank form is included.

1) TARGET PEST: List the common name (and scientific name where possible) of the pest(s) to be managed. Also specify the life stage of the pest to be managed (e.g., egg, immature, adult, pre-emergent, post-emergent, flowering, pre-seed, mature, dormant, stump etc.).

2) PRODUCT NAME: List the complete trade name of the product as it appears on the label. Also list the manufacturer [e.g., Sevin FR (Union Carbide), Garlon 4 (Dow)].

3) EPA REG. #: An EPA registration number appears on the label of every registered pesticide. Copy the number, which should always contain at least two numbers separated by hyphens, exactly as listed on the label. The first set of numbers may contain as many as six digits, while the second may contain up to five (i.e., 464-360, 264-345, 677-242-AA). Letters referring to State registrations may follow the numbers (i.e. 464-360 FL).

4) ACTIVE INGREDIENT: List the active ingredient(s) in the product by its/their approved common name(s) (e.g., carbaryl, triclopyr). If common name is not available use the chemical name (e.g., Boric Acid).

5) % or #/G ACTIVE INGREDIENT: If the pesticide is in powdered/solid form list the percentage (%) of the active ingredient. If the pesticide is in liquid form list the pounds per gallon (#/G) of active ingredient as it appears on the label.

6) MIX OF PRODUCT WITH DILUENT: Give the amount of product to be mixed with diluent (e.g., 3 lbs of Carbaryl 50W mixed with 100 gallons of water, or 3 tablespoons of Garlon 3A mixed with 1 gallon of diesel oil.)

7) PRODUCT USAGE RATE: Give the amount of product to be used per unit treated. Examples of units include acre, animal, burrow, cubic feet, linear feet, plant, and square feet.

EXAMPLE: If a 5 lb. package of a pesticide dust formulation is applied to 5 acres of turf, write "1 lb./acre."

8) PRODUCT AMOUNT USED PER APPLICATION: List the exact product amount to be used per application.

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EXAMPLE: If three one-pint bottles of 50 percent malathion are to be used per application, write: "3 pints."

9) METHOD OF TREATMENT: List the equipment to be used for pesticide application (e.g., aerosol can, bait station, direct application, dust gun, fogger, helicopter, hand placement, hand pressure sprayer, mist blower, rodding and trenching, tent fumigation, wick applicator).

10) FORM APPLIED: List how the product is formulated (e.g., bait, dust, emulsifiable concentrate, granules, liquid, suspension, wettable powder).

11) AREA OR UNITS TO BE TREATED: Give actual area that you are proposing to treat.

EXAMPLE: If you are broadcast treating 3 acres of turf, write: "3 acres-broadcast treatment."

EXAMPLE: If you are spot treating 6 trees on 4 acres of turf, write "6 trees on 4 acres—spot treatment."

12) NUMBER OF SITES: List the number of sites to be treated.

13) DESCRIPTION OF SITES: Give a brief description of the sites to be treated (e.g., cherry trees, structures, native prairie). Also include the management zone (natural, historic, development, or special use).

14) NO. OF APPLICATIONS: List the number of times that you expect to apply the dosage of pesticide described above.

15) AMT. PRODUCT USED TOTAL: List the total amount of product to be used for the entire project.

16) REGION: List the National Park Service Region to which your park reports.

17) YEAR: List the calendar year for which the project is proposed.

18) ORGANIZATION: List the official name of the park.

19) PROJECT: List the official four-letter organization code, the last two digits of the calendar year, and a unique number assigned to the project (separated by hyphens). An example is "YELL-84-01" for project number 1 in 1984 at Yellowstone National Park.

20) PURPOSE: Describe the purpose of the project.

Crop (name) protection
Employee health
Endangered species protection
Exotic plant control
Forest Insect and Disease Project
Greenhouse plant protection
Historical preservation
Household protection
Orchard protection
Ornamental protection
Pasture protection
Public health protection
Quarantine (agricultural)
Research
Roadside and trail maintenance
Site protection and restoration

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Lawn and turf protection	Soil sterilization
Livestock protection	Structural protection
Museum specimen protection	Utility right-of-way clearance

21) SEASON OR PERIOD OF APPLICATION: Use either months or seasons to complete this category. If possible, give exact dates.

22) AREAS TO BE AVOIDED: List any areas which should be avoided as indicated on the label or in the product literature (labeling).

23) AREAS TO BE TREATED WITH CAUTION: List any areas that should be treated with caution, as specified on label or in the product literature or labeling.

24) PRECAUTIONS: List any precautions such as extra safety procedures needed, as prescribed on the label, or in the product literature or labeling.

25) USE OF TRAINED OR CERTIFIED PERSONNEL: Specify the number of certified pesticide applicators (include specific federal or state applicator program and certification category) and uncertified applicators involved in the project.

26) MONITORING: List any planned monitoring activities, both pre- and post-treatment. Briefly describe method. List any thresholds that have been established.

27) PERSON TO CONTACT: List the name and phone number of the park IPM Coordinator. He/she should be able to answer technical questions about the project.

28) REMARKS: Include any comments which you feel are necessary to clarify any of the preceding items. List any nonchemical alternatives which have been considered as possible solutions to the problem and give reasons for their rejection. Give reasons for the importance of this project, such as damage or destruction of resources or threats to health, which could occur if management operations were not accomplished.

B. USDI PESTICIDE USE PROPOSAL

This form is to be submitted for all projects which require Departmental review. In addition, enclose a 10-21A and a legible copy of a current label (including any special use patterns for the state where the chemical will be applied). Projects requiring DOI approval may not be submitted via the PESTS module of COMMON. Departmental review is required for the following types of projects:

1. All pesticide uses classified as Restricted by EPA. Check with Regional IPM Coordinator for most recent listing.

2. Pesticide uses that involve aquatic application or when the applied pesticide could reasonably be expected to get into water areas.

3. Pesticide uses that can be expected to affect threatened or

Proposal Number_____

U.S. Department of Interior
Pesticide Use Proposal

BUREAU_____ STATE_____ COUNTY_____ DATE_____

AREA _____(_____)

I. Pesticide/Application:

TRADE NAME _____ EPA REGISTRATION # _____ _____

COMMON NAME _____ MANUFACTURER _____

FORMULATION _____ APPLICATION DATE(S) _____

METHOD OF APPLICATION _____ # OF APPLICATIONS _____

APPLICATION RATE(use units on label)_____

II. Pest: LIST SPECIFIC PESTS, CROP, AND REASON FOR APPLICATION.

III. Treatment site: DESCRIBE LAND TYPE OR USE, SIZE OR VOLUME, TIMING OF APPLICATION, SLOPE AND SOIL TYPE, IF RELEVANT.

IV. Sensitive aspects and precautions: DESCRIBE SENSITIVE AREAS (E.G., MARSH, ENDANGERED SPECIES HABITAT) AND DISTANCE TO TREATMENT SITE. IF SENSITIVE AREA IS UPSTREAM OR BEYOND ONE MILE FROM SITE, INDICATE "NO SENSITIVE AREAS NEARBY." LIST MEASURES TO BE TAKEN TO AVOID IMPACT TO SENSITIVE AREAS.

I will ensure that the pesticide will be applied in accordance with label restrictions and the information above.

Signed _____ Phone _____ Date _____

Bureau Approval _____ Date _____

Bureau Recommendations

Departmental Recommendations

____ Approved

_____ Date_____

Director

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endangered animal or plant species.

4. Pesticide uses that consist of one application of more than 2,560 acres.

Directions for Completing This Form:

1) PROPOSAL NUMBER: This number should be the same as the project number listed on the 10-21A (e.g., YELL 84-02).

2) BUREAU: National Park Service.

3) STATE/COUNTY: List the state(s) and county(ies) where use of the chemical is proposed.

4) DATE: Date the proposal was prepared.

5) AREA: The name of the park where the chemical will be applied (e.g., Yellowstone NP).

6) TRADE NAME: Trade name of the chemical (e.g., Rodeo).

7) EPA REGISTRATION NUMBER: The Environmental Protection Agency registration number of the chemical to be used (e.g., 345-209). (Do not confuse this with the EPA establishment number, which identifies the manufacturer, not the pesticide. The EPA establishment number will be preceded by the letters EPA EST.)

8) COMMON NAME: Common name of the proposed chemical (e.g., glyphosate).

9) MANUFACTURER: Firm producing the chemical.

10) FORMULATION: The physical or chemical nature of the compound (e.g. wettable powder, solution, dust, granules, emulsifiable concentrate, etc.).

11) APPLICATION DATE(S): The date or dates the material will be applied. (e.g., April-May, 1986, July 15, 1986; do not use Spring, Fall, etc.).

12) METHOD OF APPLICATION: Method used to disperse the chemical (e.g., cut stump, backpack sprayer, hydraulic sprayer, aerial, etc.).

13) NUMBER OF APPLICATIONS: How many times the material may be applied (e.g., 6, once per month for 3 months, or list action thresholds, do not use "as needed").

14) APPLICATION RATE: List rates and units specified on label (e.g., 0.05 lbs. of active ingredient per acre).

15) PEST: Provide specific information about pest(s) and reason for application (e.g., Kudzu, Japanese honeysuckle; to manage exotic vegetation and restore native prairie).

16) TREATMENT SITE: Provide specific information about area (e.g., 15 acres along 3 miles of Route 28 beginning at park entrance. Road banks on steeply

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sloped site and soil is silty loam).

17) SENSITIVE ASPECTS AND PRECAUTIONS: Do not list precautions listed on the label. Instead, list precautions that will be taken to protect sensitive aspects if they are present (e.g., the chemical will be applied when sensitive species are dormant or after they have set seed, etc.).

18) SIGNED: Signature of individual responsible for the project. Note: The Department will not review forms which have been submitted with this line left blank, nor will the Department review the forms if they have been signed by anyone other than the individual responsible for the project.

19) PHONE/DATE: Provide the commercial and FTS numbers of the individual responsible for the project and date the form was signed.

20) Remainder of form to be completed by Washington Office or Department.

C. Pesticide Use Log

A Pesticide Use Log must be maintained for each park area. This should consist of a loose leaf binder containing forms as illustrated at the end of Exhibit 1. Extra copies of these forms may be photocopied or obtained from the Regional or Servicewide IPM Coordinator.

Each park should maintain a running account of actual pesticide use by making an entry to the form immediately following each pesticide application. This will require submission of the needed information from Special Use Permittees, Contractors, Concessioners, etc. Proper maintenance of this log will facilitate retrieval of the pesticide use information necessary for year-end reporting. Pesticide Use Logs covering the entire calendar year will be due in the Washington Office on February 1 of the succeeding year.

Each log sheet contains enough space for fifteen entries. Use one space for each active ingredient that appears on the label. See instructions below for completing form . This form may be expanded to meet additional local reporting requirements. Anyone having difficulty with the requested calculations may contact their Regional IPM Coordinator for assistance.

1) Park: List the official name of the park.

2) Region: List the Regional Office to which the park reports.

3) Year: List the calendar year for which the listed projects are covered. DO NOT USE SAME SHEET FOR MORE THAN ONE CALENDAR YEAR.

4) Location/Project No.: List the four letter organization code for the park and the sequential project number. (e.g. YELL 84-02).

5) Date: List the date that the application was performed. If a project takes more than one day, make separate listings for each day of application.

6) Applicator: List the name of the applicator(s) who are actually applying

UNITED STATES DEPARTMENT OF INTERIOR
NATIONAL PARK SERVICE
PESTICIDE USE LOG

PARK:
REGION:
YEAR:

	LOCATION/ PROJECT NO.	DATE	APPLICATOR	TRADE NAME	ACTIVE INGREDIENT	EPA REG. NUMBER	PEST	AMOUNT OF PRODUCT	AREA TREATED	AMOUNT 100% ACTIVE INGRED.
AMPLE	YELL. 84-02	6/22 84	G. Jones	Sevin	Carbaryl .50WP	324-560	Corn Earworm	10 lbs	5 acres	5lbs

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the pesticides. This includes both contract Pest Control Operators, Special Use Permittees, etc.

7) Trade Name: List the trade name of the pesticide that appears on the label (e. g. Dursban TC).

8) Active Ingredient: List the common name of the active ingredient in the product (e. g. Chlorpyrifos). If more than one active ingredient is contained in a particular product, make separate entries for each active ingredient.

9) EPA Reg. Number: List the complete EPA registration number for the product.

10) Pest: List the target pest(s) which were treated for each application.

11) Amount of Product: State the actual amount of product applied.

EXAMPLE: If two 1-pint bottles of 22.5 percent chlorpyrifos solution was used then list "2 pints."

12) Area Treated: State the total area treated in square feet or acres.

EXAMPLE: If two acres of weeds were broadcast with glyphosate, then state: " 2 acres-broadcast."

If 15 trees in an area of 30 acres were spot treated, state: "15 trees on 30 acres - spot treated."

13) Amount 100% Active Ingredient: State the total amount of active ingredient used in terms of pounds of active ingredient. Examples are given below to illustrate the information needed to make necessary calculations.

EXAMPLE: Powders, Dusts, etc. For pesticides which are purchased as powders or dusts. Multiply the amount of powder or dust used by the percent of the active ingredient. Then divide by 100. This gives the "Amount of 100% Active Ingredient."

EXAMPLE: 4 oz. of 10 percent carbaryl dust are applied to ornamental plants. 16 oz. = 1 pound. 4 oz. = 1/4 or 0.25 pounds. Since the carbaryl dust contains 10 percent active ingredient, make the following computation: 10/100 = 0.10. Then multiply the weight of product used (5 lb) by the proportion of active ingredient (0.10) to give the "Amount of 100% Active Ingredient." 0.25 x 0.10 = 0.025 lb.

EXAMPLE: Solutions, Liquids, Emulsions, etc. If the product is purchased as a liquid, then the volume used

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must be converted to units of weight (lbs). Pesticide labels contain a conversion factor to make this calculation.

EXAMPLE. The label for Dursban 2E insecticide states "contains 2 pounds of chlorpyrifos per gallon.'' The applicator mixes 2 fl. oz. of the product with 2 quarts of water and applies it according to the label instructions. To determine the "Amount of 100 percent Active Ingredient" used, the following calculations are necessary:

a) Convert fluid oz. to gallons

32 fl. oz. = 1 quart, 4 quarts = 1 gallon, 128 fl. oz=1 gallon, 2 fl. oz./128fl oz per gal= 0.016 gal. of product used.

b) Since the product contained 2 pounds of chlorpyrifos per gallon, make the following calculations to determine the actual weight of active ingredient used.

2 lb chlorpyrifos x 0.016 = 0.032 lbs.

THE CENTER FOR URBAN ECOLOGY (CUE) is a research and extension facility designated to address resource management concerns in the National Capital Region 342-1443.

Dr. Wiliam Anderson, Chief Scientist, National Capital Region

Mr. Dave Daniels, Site Manager

Ms. Carol DiSalvo, IPM Assistant/Entomologist

Dr. John Hadidian, Wildlife Biologist

Ms. Christine Haggerty, Pest Management Assistant

Dr. Richard S. Hammerschlag, Chief, Center for Urban Ecology

Mr. John Hoke, Biological Engineering Specialist

Ms. Janet Jagdhane, Administrative Officer

Dr. James Patterson, Soils Agronomist

Mr. Seth Riley, Park Ranger/Technician

Ms. Libby Roberts, Horticulturist

Mr. John Short, Soils Scientist

Dr. James L. Sherald, Plant Pathologist

Dr. Lindsey K. Thomas, Plant Ecologist

IPM INFORMATION MANUALS: AVAILABLE THROUGH
NCR - IPM COORDINATOR, CENTER FOR URBAN ECOLOGY (342-1443)

NATIONAL PARK SERVICE
IPM INFORMATION PACKAGES

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*XLI and XLV have been combined with the preceeding IPM package.

NATIONAL PARK SERVICE INTEGRATED PEST MANAGEMENT TECHNICAL TRAINING VIDEOS

Videos can be borrowed from the National Capital Region Training Office and from The Center for Urban Ecology. Videos may be purchased from: Technical Training Videotapes, National Park Foundation, P.O. Box 57473, Washington, D.C. 20037.
Cost: $65.00 each.

1. Pesticide Applicator Safety

17 Minutes : Color
National Park Service
Vegetation and Wildlife Division
202-343-8100

Because pesticides by design are biologically active and toxic, they pose potential risks to human beings. Those who handle pesticides-particularly applicators who mix, load, and apply pesticides-are the primary group at risk. This videotape exhorts NPS pesticide applictors to handle chemicals more carefully and demonstrates how to use protective clothing and equipment. The videotape also discusses acute and chronic poisonings, reading the pesticide label and material safety data sheets accurately.

2. Structural Inspections - A Way of Managing Wood Inhabiting Insects

23 Minutes: Color 1987
National Park Service
Vegetation and Wildlife Division
202-343-8200

Many of the National Park Service historic wooden structures are vulnerable to insect attack and bio-deterioration. This videotape follows Dr. Harry Moore of N.C. State University, an entomologist and author of the text "Wood-Inhabiting Insects in Houses," as he enacts an inspection of a typical Park Service wooden structure for the presence of wood inhabiting insects. The videotape's emphases are on recognizing signs of insect damage, learning how to identify different types of insect damage to wood, and sources of infestation. It also briefly describes insects that do the most damage to wooden structures-the subterranean and drywood termites, wood-boring beetles, carpenter ants, and carpenter bees.

3. Subterranean Termite Biology

11 Minutes: Color 1987
National Park Service
Vegetation and Wildlife Division
202-343-8200

This videotape estabilshes the realationship of prevention and control procedures to the biology and habits of subterranean termites. This videotape, a companion to the structural inspection videotape, uses edited footage of insect photography from two previously produced tapes, Dr. F.E. Wood's "Subterranean Termites" and Shell International Chemicals's "Thief in the Dark", with a new script and additional NPS footage.

4. Crack and Crevice Treatment for Cockroach Management

13 Minutes: Color 1987
National Park Service
Vegetation and Wildlife Division
202-343-8200

This program follows a pesticide applicator and a trainee as they treat a National Park Service food-handling operation and an office for cockroaches. The program focuses on the IPM techniques of sanitation, caulking as a mechanical control, site monitoring, and use of a low toxic pesticide treatment (boric acid dust).

5. Integrated Pest Management

15 Minutes: Color 1985
National Park Service
Vegetation and Wildlife Division
202-343-8200

This videotape embodies the National park Servcie's IPM philosophy. The tape discusses how IPM utilizes various biological, physical, and chemical controls and habitat modification techniques. The tape also uses actual case studies to demonstrate how the National Park Service has employed IPM techniques to resolve pest management problems.

6. Ornamental and Turf Pest Managment

DRAFT

10 NOV 1989

GUIDELINES FOR THE MANAGEMENT OF WEEDS IN TURFGRASS

The National Park Service manages turfgrass in three of its management zones: Developed, Special Use, and Historic. Within each management zone the visual objective for turfgrass quality will depend on the management objectives established for the park and the management resources available.

Generally, turfgrass can be classified into three classes: A. Ornamental Turfgrass; B. Recreational Turfgrass; and C. Greenspace Turfgrass. These classes will determine the type and level of maintenance each should receive.

Classes can be used in Integrated Pest Management (IPM) to determine thresholds and management strategies for specific pests. The following guidelines have been developed specifically for weed management in turfgrass to assist in determining where and when the use of herbicides would be appropriate.

The intent of these guidelines is to sustain the quality of turfgrass appropriate for specific sites, while minimizing dependency upon herbicides to achieve this quality. This can best be achieved by using a fully integrated turf management program which defines the site objectives, assures objective monitoring, and encourages cultural management practices.

TURFGRASS CLASSIFICATION

A CLASS A - ORNAMENTAL TURFGRASS:

Lawns classified as Ornamental have the highest visual quality objective. Turfgrass must appear uniform in color and texture with weeds and bare spots unnoticeable to the general public. Ornamental lawns are exposed to minor foot traffic and receive the highest level of maintenance. Ornamental lawns provide the setting for memorials and other significant sites and features. Considering the intensive maintenance these areas require and that visual quality necessitates limited visitor use, managers should restrict the Class A designation to the minimum area necessary to achieve the visual management objective.

B CLASS - B RECREATIONAL TURFGRASS:

Turfgrass which provides the setting for certain passive recreational and athletic activities can be classified as Recreational Turfgrass. Class B areas would include small urban parks and some playing fields for organized sports, as well as turfgrass surrounding offices, parking lots, and other support facilities. Although such areas may have ornamental significance, the visual quality and level of maintenance is less demanding than Ornamental Turfgrass. Visitor use is common and some weed infestation is tolerable. The uniformity in color and texture is not as critical as in Ornamental areas.

CLASS - C GREENSPACE TURFGRASS:

Greenspace turfgrass encompasses large areas that receive minimal maintenance other than mowing. The aesthetic objective for the site is achieved simply by the presence of turf and not by its quality. Greenspaces would include large picnic and informal recreation areas, parkway medians, and roadsides.

Managers should classify all turfgrass within a park into the three classes. In some parks all three classes may occur contiguously. The classification scheme allows for managers to exercise their judgment and experience in classifying turfgrass. Classification, however, should be based on the Parks Statement for Management, and other mandates and factors establishing the visual objective for the site. In historic areas, class designation should be supported by documentation describing the appearance of the site during the period portrayed. All site classifications should be defined in the Resource Management Plans and reviewed routinely to assure their proper designation.

ACTION THRESHOLDS:

The application of herbicides in conjunction with other weed management tactics may be necessary to achieve the visual quality objective. Proposals to apply herbicides (Pesticide Proposal Form 10-21A) should be supported by the site classification and quantitative monitoring data showing that the Action Threshold (AT) for the class has been reached. The AT is expressed as the maximum percentage of weed cover allowable before herbicide applications can be made.

Turfgrass should be monitored routinely and systematically, recording quantitative measures of weed cover.

CLASS A - ORNAMENTAL TURFGRASS

SPOT TREATMENT:

Spot treatment may be considered when an AT of 15-29% weed cover is reached. Treatment must be limited to those areas that have reached the AT and can be sprayed with a backpack or other similar single nozzle, small capacity sprayer.

RECOVERY TREATMENT:

An AT of 30-49% indicates a possible need for broadcast application of herbicides by backpack or tractor mounted, multi-nozzle boom sprayer. Treatment must be preceded by a complete review of the turf management program to determine why the weed level reached the Recovery AT. The review will examine: the level of use (abuse), compaction, turf variety, mowing height, moisture management, fertility, pH, and other factors considered pertinent to maintain Class A turf.

Herbicide applications must be used in conjunction with other tactics to remedy the management deficiencies or site factors responsible for weed infestation. Recovery treatments will not generally be approved for

consecutive years.

RENOVATION:

When the AT reaches 50% weed cover, or greater the area warrants complete renovation. Renovation will be preceded by broadcast application of glyphosate or other similar broad spectrum, post-emergent, short residual herbicide that kills all vegetation. The treatment must be preceded by review of the overall turf management program as described for recovery treatments. The site will be seeded or sodded as appropriate. All other management or site deficiencies determined in the review must be corrected.

CLASS B - RECREATIONAL TURFGRASS

SPOT TREATMENT:

Not permitted in recreational turfgrass.

RECOVERY AND RENOVATION:

As described for Class A turfgrass.

CLASS C - GREENSPACE TURFGRASS

Herbicide applications are not permitted on Class C turfgrass.

MONITORING

Monitoring is the most important component of any IPM program. Only through routine monitoring can a manager be aware of changes in turf status. A proposal to apply herbicides must be supported by objective monitoring data demonstrating that the AT has been reached. Visual estimates are often inaccurate and therefore unacceptable as justification for a herbicide request. In addition to determining the percent weed cover, monitoring also determines the percent bare ground which is susceptible to weed invasion. Monitoring also facilitates the identification of the weed species present. Species identification is critical in developing the appropriate management strategy. Post treatment monitoring provides a measure of the efficacy of the overall management program.

A variety of monitoring techniques and devices can be used to measure the weed infestation (Appendices A&B). The procedure and intensity in which monitoring is applied will depend on the size and uniformity of the area being examined. If the area of interest is not uniform in cover, it should be subdivided and monitoring performed in each subdivision. A minimum of 5 monitoring points should be used in any size area and no less than 10 per acre. The more

monitoring points used, the more definitive the assessment will be. However, monitoring must be simple, quantitative, and expeditious. Before monitoring, there must be a consensus as to what constitutes a "weed" since some species such as bermudagrass, annual blue grass and clover may or may not be considered a weed depending on the site and its management.

Monitoring in small areas can be performed by randomly selecting monitoring points by the toss of a marker (rock, ball etc.) The marker can be thrown at 5 random points in an M pattern spread over the expanse of the area to be examined (Appendix A). In large areas, 1 acre or more, a series of straight or zigzag transects may be used with monitoring points predetermined by measure or the random toss of a marker along the transect line. Measurements at the monitoring points can be made in a variety of ways. At each monitoring point a specific area of turf should be examined and the percentage of turf, weed or bare ground determined. Weed species should be identified and if possible the species percentage determined. A reliable method is to use a sampling frame (wood or pipe), that has the inner dimensions of one square meter, and has been divided by strings into 100 square decimeters (Appendix A). Each of these smaller string squares is examined and rated as to whether turf, weed or bare ground occupies 50% or more of the square. It is helpful to have at least 2 people independently make the rating and a consensus reached for each square. A tally of the 100 squares will determine the percent turf, weed, or bare ground for each square meter. The data from all the square meter sampling points are then averaged to determine the overall percentage of turf, weed or bare ground for the site (Appendix A). Other monitoring devices can be used (Appendix B).

SAFETY

All herbicide applications must be made in the early morning or evening before or after visitors are present. Treatments must be made in a safe and responsible manner either by a licensed applicator or individual working under the "line of sight supervision" of a licensed applicator. Treated areas must be posted (Appendix C).

PESTICIDE APPROVAL REQUEST (FORM 10 - 21 A)

In addition to the information already required, requests for herbicide use on turfgrass must include:

1.) Turfgrass classification, Class A or B.

2.) The percent weed infestation and weed species present.

3.) The method used to determine the level of infestation, pre and post treatment.

4.) Statement of other management measures that will be taken.

GUIDELINE SUMMARY

ACTION THRESHOLD % Weed Cover	TURFGRASS CLASS TREATMENT OPTIONS		
	A	B	C
0-14	X	X	X
15-29	SPOT	X	X
30-49	RECOVERY	RECOVERY	X
50 <	RENOVATION	RENOVATION	X

X Cultural weed management practices only.

WEED MONITORING FORM

SITE: CLASS:

EMPLOYEE: DATE:

MONITORING POINT #	WEED RANK	>50% WEED COVER	>50% BARE AREA	>50% TURF

TOTAL:

TOTAL - #SITES:

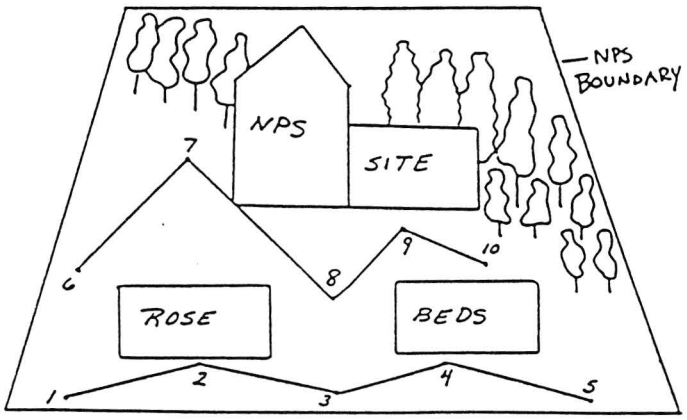
Appendix A

WEED MONITORING FORM

SITE: Historic Haven — CLASS: A
EMPLOYEE: Lee Fescue 343-8101 — DATE: 4-10-89

MONITORING POINT #	WEED RANK	>50% WEED COVER	>50% BARE AREA	>50% TURF
1	GOOSEGRASS CRABGRASS	5	0	95
2	PLANTAIN CRABGRASS	15	10	75
3	GOOSEGRASS	5	0	95
4	PLANTAIN CRABGRASS	8	16	76
5 *	NUTSEDGE	12	0	88
6	CRABGRASS GOOSEGRASS	3	2	95
7	NONE	0	0	100
8	GOOSEGRASS CRABGRASS	35	20	45
9	PLANTAIN GOOSEGRASS	20	10	70
10	SOME CRABGRASS	13	4	83
TOTAL:		116	62	822
TOTAL ÷ #SITES:		11.6%	6.2%	82.2%

* MONITORING SITE #5 IS VERY WET - WILL HAVE PLUMBER CHECK PIPES



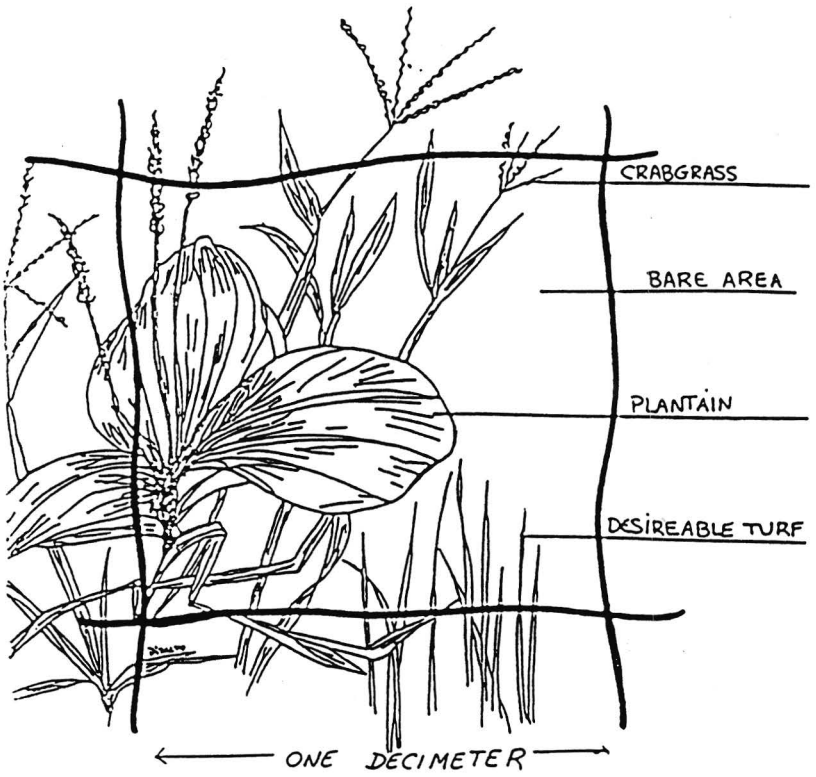
Monitoring Weeds in Turf

APPENDIX A

MONITORING POINT #2

B	T	T	T	T	T	T	T	T	T
T	T	T	T	T	T	T	T	T	T
T	T	T	W	T	B	B	W	T	T
T	T	B	T	B	T	T	B	B	T
T	T	T	T	W	T	W	B	T	T
T	T	W	T	T	W	T	W	T	T
T	T	B	T	B	T	T	W	T	T
T	T	T	W	T	W	T	T	W	T
T	T	T	W	T	T	W	T	T	T
T	T	W	T	T	T	T	W	T	T

ONE METER
MONITORING GRID



THIS DECIMETER SQUARE HAS 50% WEED COVER. IT DOES HAVE SOME BARE AREA BUT SINCE WEED COVER IS GREATER, COUNT IT AS A "WEED SQUARE."

EVALUATE EACH OF THE 100 DECIMETER SQUARES AND COUNT THE NUMBER OF SQUARES DETERMINED TO BE TURF-T, WEED-W, OR BARE-B. RECORD THIS ON THE MONITORING SHEET.

Appendix B

IPM Methods

Monitoring Weeds In Turf

Sheila Daar and William Olkowski

When developing an IPM program - managing weeds in turf, a method for measuring the rise or fall of weed populations is a necessary tool. Information on weed dynamics is key to evaluating the effectiveness of strategies and tactics used to reduce weed populations.

This data is also useful when establishing "weed tolerance levels" -- an important component of turf IPM programs. The tolerance level concept recognizes the fact that some percentage of weed growth is inevitable in any turf area. The objective of the weed management program is to keep weeds from exceeding the percentage deemed tolerable.

A simple method for determining the percent of weeds present in an athletic field or other turf areas, and for monitoring weed trends over time, is based on the use of transects.

A turf transect is a line (without width), drawn through one or more representative areas of a grass field. By periodically recording the percentage of weeds vs. grass along the transect, turf managers can quantify the level of weed growth present in the turf, and determine if treatment is needed (see *IPHP* IV(9)3 for non-pesticide treatments).

The following example describes how to monitor weeds in a football field, but any configuration of turf can be monitored with this technique by simply locating the transect lines so they pass through both heavily and lightly-used (e.g. "representative") turf.

THE TRANSECT METHOD

1. The first step is to measure the length of the field to be monitored, decide at how many points along the transect to record data (a minimum of 20 sampling points is recommended), and where along the transect line those data collection points will occur. Box A details the process for making these calculations.

2. Establish three parallel transect lines along the length of the field. Use the center of the field and the two sets of "hash marks" as permanent transect markers (see figure 1).

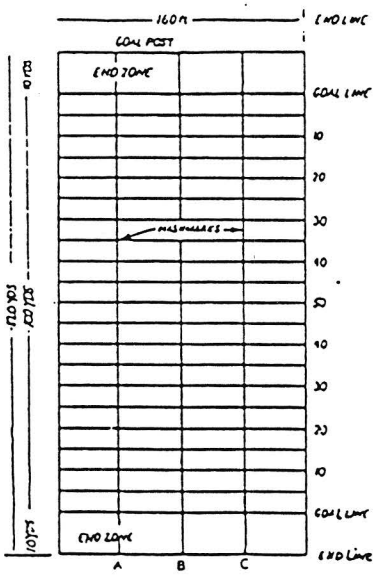


Figure 1. A high school football field with transects drawn over hashmarks and down the center ---where the most wear occurs.

NOTE: Three transects will give sufficient data to indicate percentage weed cover in the total turf area. If time is limited, information recorded from one transect across a representative area of turf (in this case, down the center of the field) may give sufficient indication of weed trends for management purposes.

3. At the beginning and end of the playing season, stretch a line of string or other material along the three transect lines. The string can be laid directly on the ground.

4. Beginning at one end of the first transect, walk 9 paces (see Box A), stop and look at a 3 x 3 in area (e.g. the circumference of a softball, or the lid to a 1-lb coffee can, etc.) immediately in front of the toe.

If this area contains part or all of a weed, check the "yes" box on the first line under "Transect A" on the monitoring form (figure 3). If you know the identity of the weed, write it down". It is well worth the effort to identify the weed species, as they often serve as indicators of the underlying soil or cultural problems leading to weed growth (e.g., knotweed indicates soil compaction and inadequate water, English daisy indicates poorly-drained soils, etc.).

If the toe sample area contains grass, check the "no" box on the monitoring form. If 25% or more of the toe area sample is bare soil, check the box marked "bare". If less than 25% bare, but a weed is present, check "yes".

Continue pacing along the transect line, stopping every 9 paces and marking the appropriate box on the form. Repeat this activity along the two other transect lines.

5. To calculate the relative percentage of weeds, total the number of boxes marked "yes" in each column. Divide this number by the total boxes in all columns. The resulting figure represents a relative percent weed cover in the turf. Do the same calculation with the boxes representing bare ground. This will indicate percent area that will become weedy if not seeded to grass.

6. By collecting data from the transects at the beginning and end of each season, the turf manager can spot emerging problem areas. For example, if several boxes in succession are marked "yes", indicating weed presence, a closer look at this area on the transect is warranted. Usually such "clumping" of weedgrowth indicates exceptionally heavy wear on the turf, although structural problems such as severly-compacted soil, a broken irrigation line, inoperative sprinkler head, scalping of the turf due to uneven grade, etc. also may be indicated. These conditions create habitats for weeds. If these conditions are spotted

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• An excellent pictoral reference tool to use when identifying weeds in turf is entitled "*Turfgrass Pests*," Pub #4053, available for $4.00 from Ag. & Nat. Res. Div., U of Calif., 6701 San Pablo Ave., Oakland, CA 94608. 415/642-2431.

early enough and corrected, weeds can be displaced by grass.

By monitoring the turf area from season to season, the manager can tell if weed populations are rising, falling, or remaining relatively stable. This information will indicate whether or not current turf management practices are keeping weeds at or below the agreed-upon tolerance level. If weed populations are rising, changes in management practices are indicated.

BOX A. TRANSECT CALCULATIONS

1. Measure the length of the turf area to be transected and convert this figure to feet (e.g. a football field is 120 yards long including end-zones. 120 x 3' = 360 feet).

2. Measure the length of the pace of the person doing the transect. To do this, slowly walk a known length (e.g., 20 feet), count the number of paces it takes to cover this distance (e.g. 10), and divide the distance by the number of paces (20 ft / 10 paces = 2 ft). This figure represents the average length of the pace.

3. Divide the length of the field by the length of the pace (360 ft / 2 ft = 180). This establishes the number of paces it takes to walk the transect.

4. Divide the number of paces by the number of samples to be recorded (a minimum of 20 samples is recommended). 180 / 20 = 9. Thus, in this example, a sample will be taken every 9th pace along the transect.

Figure 2. SAMPLE TURF TRANSECT/WEED MONITORING FORM

Park or Athletic Field:_____ Date:_____

Data Collected By:_____ Length of Pace:_____

Distance Between Sampling Points On Transect:_____
(Sampling points 3'x3' area)

No. of Transects:_____ Length of Transects:_____

Sketch of Location of Transects:

Transect "A"			Transect "B"			Transect "C"		
Yes	No	Bare	Yes	No	Bare	Yes	No	Bare
1. /	/	/	1. /	/	/	1. /	/	/
2. /	/	/	2. /	/	/	2. /	/	/
3. /	/	/	3. /	/	/	3. /	/	/
4. /	/	/	4. /	/	/	4. /	/	/
5. /	/	/	5. /	/	/	5. /	/	/
6. /	/	/	6. /	/	/	6. /	/	/
7. /	/	/	7. /	/	/	7. /	/	/
8. /	/	/	8. /	/	/	8. /	/	/
9. /	/	/	9. /	/	/	9. /	/	/
10./	/	/	10./	/	/	10./	/	/
11./	/	/	11./	/	/	11./	/	/
12./	/	/	12./	/	/	12./	/	/
13./	/	/	13./	/	/	13./	/	/
14./	/	/	14./	/	/	14./	/	/
15./	/	/	15./	/	/	15./	/	/
16./	/	/	16./	/	/	16./	/	/
17./	/	/	17./	/	/	17./	/	/
18./	/	/	18./	/	/	18./	/	/
19./	/	/	19./	/	/	19./	/	/
20./	/	/	20./	/	/	20./	/	/

Average % weedgrowth:_____ Average % bare area _____

(Add the total number of weed samples found in transects "A", "B", & "C". Divide this number by 60 (the total samples taken). The result is the average percentage of weeds growing in the turf area. Follow the same procedure to calculate percentage of bare area.)

APPENDIX C

POSTING

Treated areas should be posted at all major access points for 24 hours after treatment. Longer periods may be required by the label or state regulations. Signs must be at least 4x5" and printed in easy to read lettering. The sign must include the phrase "Keep Off" with appropriate symbol. It must also include a phrase "Pesticide Application", "Lawn Care Application" or similar statement.

EXAMPLE



Meadows are an early, temporary stage of succession from cultivated or bare land in a forest ecosystem. The meadow habitat supports a wide diversity of flora including grasses, rushes, sedges, ferns and wild flowers and fauna such as butterflies, mammals, birds, reptiles, and insects.

The diversity of life in meadows makes them interesting to naturalists and visitors. Meadows can be an attractive, economical transition from mowed lawn to natural woods. The existence of this habitat is disappearing as farm lands are converting to home, office and shopping mall use and open areas are planted in lawn.

Where to have meadows and how to start and manage them are discussed. Specifics on the timing of mowing schedules, shape and size, monitoring, problem exotic and native pest plants, planting native flowers and grasses, and public relations are also covered.

LOCATION OF MEADOWS

In choosing a location for meadows, look for areas that are not being used for particular purposes like baseball and picnicking. Narrow or wide expanses of lawn are suitable. Meadows do not need to be large and rectangular. Flowers and animals respond even to very small areas. A minimum size is about 20' x 20'. Similarly a 10-20' width for a long, narrow meadow is productive.

STARTING A MEADOW

Most meadows in the mid-Atlantic region of the United States grow effortlessly in areas that were mowed lawn or abandoned farm land. Therefore the simplest and most effective way to achieve a meadow is to simply not mow the desired area and let it grow for a year. During that time, the site should be monitored in each season of the year to note: what species do grow, including the colors, heights and textures; what animals use the area; which animals are not there but would be desireable to entice. Many butterflies need specific plants for their development.

MEADOW MANAGEMENT

Mowing: Since a meadow is a temporary stage, management is necessary. National Capital Region is in the Eastern Deciduous Forest Ecosystem, and unmanaged land grows trees. Woody vegetation in the form of blackberries and forest tree species quickly germinate and spread in an unmowed area. Just as lawn needs to be mowed to remain lawn, so a meadow needs to be mowed at least once a year to remain a meadow. Meadows should be mowed with a rotary mower set high, at about 6". The ground up leaves, flowers and stems should be left in place; there is no need to collect the organic debris. The mowing should occur in March, June or November. March (April) is the 1st choice, June the second, and November the third. By mowing in March the plants provide seed, perching places, and cover for the diversity of wildlife that use the meadow in the winter. A potential problem with a March mowing might be that the ground would be too wet to mow and the mowing would be postponed to April. If the meadows are mowed in June, an advantage is that the cut will diminish the abundance of exotic cool-season lawn grasses for the next year and severely shock the woody vegetation. However, flower buds of the summer and fall blooming species will also receive a setback by being mowed. Most do regenerate. In November the ground is firm and labor is usually available, but the food and cover for animals for the winter will be eliminated.

Before any mowing, a walk through should be made to see if there are any nesting birds or animals. The nesting sites then should be given a wide protected unmowed area or the mowing should be postponed for a few weeks.

Sledding Hills: Favorite sledding hills should be mowed in November.

Shape of Meadows: The most usual place for a meadow in NCR is in lawn areas that come up next to the woods. In this situation, a strip of mowed lawn should be maintained, usually next to a road, so that the unmowed area, the meadow, is defined and looks planned. The meadow/lawn edge should be gracefully curved, following the curve of the road or the curved edge of the woods. If the annual mow is in the spring, when the grass is growing rapidly, the lawn/meadow edge and paths might need to be marked 2-3 times. Marking the line can be done in several ways: liming the mow line; staking the mow line; walking the mow line by walking in front of the mower. If the meadow is large enough for a path, meander a tractor wide pass through it.

CONCERNS

Pest Plants: A CAUTION!! If there are aggressive exotic pest vines or shrubs, such as multiflora rose, bush honeysuckles, Porcelain-berry vine, Asiatic bittersweet, Japanese honeysuckle, cultivated viburnums, *Miscanthus sienensis* in the woodedge, a 10' path should be maintained between the woodedge and the meadow -- so that the exotic pest plants do not spread into the meadow. Once the exotic pest plants are in the meadow, getting rid of them is very labor intensive. The simplest "control" at that point is to return the problem area to mowed lawn, monitor the site until the exotics are eradicated and then return the area to meadow. Exotic pest plants are known to still be a problem after 5 years of being mowed 15 times a year. Don't let the problem start. Three Native species can cause negative reactions: poison ivy and Great and common ragweeds. They can be treated as part of the plant composition of the meadow, or mowed to control their growth.

Yellow Jacket Nests: Meadows should not be mowed between July 1 and November l, due to the possibility of stirring up yellow jacket nests.

Planting: If the meadow needs more or different species, determine the indigenous species requirements appropriate for the site: Coastal Plain/Piedmont Plateau; dry/wet; shady/sunny; soil type, etc. The species can be planted either as seeds or nursery grown plants. The plantings should imitate the attractive field "meadows" one has seen. Swathes of color, texture and size are in a very different pattern from a cultivated, landscaped garden. Specific planting directions for each species can be obtained from reputable native plant nurseries. In general, nursery grown plants, planted in the fall or early spring are more reliable than seed. Winter, after the soil has frozen, is an ideal time to broad-cast seed over undisturbed soil. The natural freeze/thaw cycles will work the seed into the soil. Tillage or cultivation should be avoided to prevent exposing and encouraging waiting weed seeds.

Only native plants common to an area should be planted. Those native species that naturally occur only infrequently or rarely should not be collected or planted in the early stages of setting up a meadow.

With natural areas disappearing, it is important to protect native habitats and species. Too often, the showy, unusual and infrequent native species have been dug in the wild, often a National Park, for transplanting. This practice harmed the original habitat, and most often the transplanting was not even successful. The most environmentally ethical practice is to buy nursery propagated plants of species that are of common occurrence. As requests are made for nursery propagated plants, they will become more available.

Plantings can be done before the meadow grows for the first year, or in later years as a supplement. Most meadows in Rock Creek Park in the natural areas have been allowed to change without supplemental plantings.

The best, most diverse, meadows grow from those areas where the lawn was not class A, but rather had lots of plants other than lawn grasses. If the lawn is thick with Tall fescue and Kentucky bluegrass, and a display of wildflowers is desireable, plantings will be necessary. If a showy display is not necessary immediately, the grassy meadow still will be interesting and diverse, animals will visit, and interpreters will have "a field day". The meadow will just not be as showy from a distance.

Meadow Coordination: Meetings and coordination are necessary for a successful meadow program. A meadow coordinator makes management easier. S/he keeps track of: dates for mowing; meadow shapes; monitoring. S/he evaluates the meadows: are there enough paths? are paths causing erosion? what plants should be added to the meadow? what is happening in the meadow? Problems and 'great happenings' need to be discussed in varying degrees with the Offices of the Superintendent, Interpretation, Resource Management and Maintenance. Relevant findings need to be shared with the Interpreters. Work orders for Maintenance need to be written -- to remove fallen limbs or pick up trash. Neighbor or visitor meadow letters need to be considered and responses done.

What Happens If You Just Let the Lawn Grow: In Rock Creek Park meadows began growing in 1977. Detailed records were kept on succession for the 1st, 2nd, 3rd and 8th years. Cool season lawn grasses are replaced by native grasses and wildflowers. Lawn grasses are bred to thrive as mowed lawn. When they are not mowed, and grow to maturity they do not hold their own in competition. Lawn plants dominate the first year, but by the third year wildflowers, not always showy, dominate.

Plants like dandelions, plantains, bermuda and crab grass die out, for the same reasons that the lawn grass species do not succeed. Short plants die out and taller species replace them. Diversity of plants increases immediately. If present, Great and Common ragweeds persist and increase in frequency each year. Even after 12 years, what will grow in a meadow is not predictable; something new grows each year.

Public Relations: Let the neighbors and visitors know about the new habitat. Signs, fliers, a program at Nature/Visitor center, letters to neighborhood groups, local newspaper coverage, local radio and TV coverage. At Rock Creek Park we had the 4th graders at a local elementary school compose meadow poems. The poems were painted on signs. Then the kids came to the park and were filmed installing their poems.

Economics: If the meadows are small there is not much, if any, money saved. The larger the meadow, the more savings. The money and time spent mowing an area once a year instead of 15 times a year adds up. Also, meadows do not get limed or fertilized.

QUESTIONS TO CONSIDER WHILE SELECTING MEADOWS

Deciding on a particular vegetation stage.

What are the possible vegetation stages for a given area?
Which stage is missing? wanted?
Will this stage need to be managed to be maintained?
How will this stage be managed?
Can the necessary machinery and people reach the site to maintain it?

Considerations about the suitability for a particular vegetation stage.

What is the best use of the site: lawn? meadow? brambles? shrubs? trees? successional? recreation? vista?
Does the area's current use conflict with its becoming a meadow? Is the area currently a ballfield? a needed picnic grove? an eroding area?
What would a meadow add to or take away from a given area: less lawn? more diversity of habitats, flora and fauna?
Would the new habitat add to visitor enjoyment? interpretive opportunities? resource protection?

Deciding on location.

Site. A meadow can be next to a creek, an extension of a woodedge, in a swale, on an eroded slope, or in the middle of the woods.
Size. A meadow can be a variety of sizes or shapes.
Discuss locations with the Superintendent and Division Chiefs for their perspectives.

Grow a meadow.

Discuss implementation scheduling with Maintenance.
Discuss interpretation opportunities with Interpretation.

MANAGEMENT OF ORNAMENTAL POOLS AND PONDS

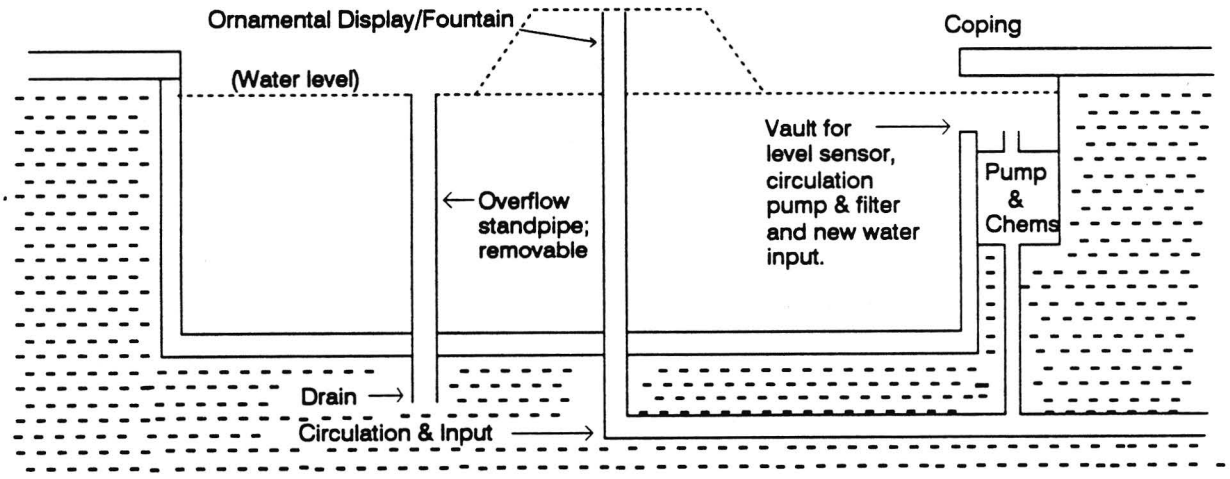
Small architectural pools and fountains, along with larger ones such as the Reflecting Pool, play an important aesthetic role in the National Capital Region. They help provide the setting for the monuments and memorials located in and around Washington, D.C. Even though there are other kinds of water bodies that range from constructed--such as the C & O Canal and the ponds at the Kenilworth Aquatic Gardens--to natural, such as Rock Creek that flows through Rock Creek Park, this chapter will focus on the management of architectural pools and ponds located in National Capital Region. Two management modes may be considered. One is synthetic, relying on chemical or other hard technology to sustain essentially clear and sterile water for formal architectural purposes. The other is an ecologically-based system that is compatible with those ponds accenting flora and fauna within their informal mission.

SYNTHETIC MANAGEMENT OF ARCHITECTURAL POOLS AND FOUNTAIN SYSTEMS

Synthetic management is often implemented with the smaller, concrete or masonry impoundments that include some formal architectural feature such as the shallow rectangular pool located in Pershing Square as well as similar pools located further down Pennsylvania Avenue, or the lily pools and fountain located in Rawlins Park at the north entrance of the Department of Interior but may also be utilized for larger water bodies such as the Reflecting Pool.

These pools are intended to utilize water as a formal design feature to compliment statuary and landscape components. Such water bodies must appear clean, function in a manner that contributes to the architecture associated with the water bodies, and be correspondingly free of conspicuous mechanical involvement that would distract from their architectural purposes (aquatic-system mechanics are usually out of sight in vaults or otherwise obscured from public view).

System Mechanics: Architectural pools usually include a plumbing system to keep them filled, clean and attractive. A typical schematic view of such a system is shown below:



Basic System: In its simplest form, the masonry water body will contain a valve-controlled water supply and drain. The system may also incorporates a standpipe for the automatic overflow of excess water into a drain. The water supply mechanism is usually incorporated into a circulation system where a float control automatically adds water to make up for evaporative loss but should also contain a manually controlled valve.

The typical circulation system incorporates an electric pump to drive the aquatic fountain display, wherein the pool water is continuously pumped from the water body, through the pump and its plumbing out to the ornamental display and then back into the main water body.

Recirculation systems require a means for keeping large trash from getting into the circulation plumbing and clogging the pump or water display nozzles. This filter consists of a course-weave screen box or basket through which incoming water flows; the screen simply traps larger particulate matter from the pool water. Traps of this sort require periodic removal of collected trash. If not attended to, these filters will become clogged, gradually arresting the flow of the circulation system which may result in destruction of the pump and associated plumbing.

Circulation System Functions: A circulation system, with or without an ornamental display, is of value in maintaining good water quality. Stagnant water is prone to developing some filamentous algal growths. While these concerns are of less importance in very small pools and fountains, where a periodic water change is easily managed, the facility for circulating water is a virtual requirement for larger water bodies. Where circulation systems and associated aeration have been lacking, such as in the Reflecting Pool and Constitution Gardens Lake, periodic, almost unmanageable algal blooms are a constant threat. Chemical treatment can, of course, be employed but a total reliance upon stringent chemical water management is costly and subject to criticism--particularly where impounded water ladened with such chemicals is ultimately discharged into nearby natural water bodies.

Recirculation of water within our pool systems serves another important purpose. In addition to the water quality maintenance, it reduces the use of treated city water. Most of the water bodies located on or near the Mall are equipped with water recirculation systems. As such, the requirements for water is limited to filling and then maintaining proper level by automatic feed of new water to make up for evaporative losses. This becomes critically important during times of water shortage when phased reductions of water use become necessary or mandatory. One of the first kinds of facilities to be shut down would be flow-through pool systems.

Those pools that activate aquatic displays by the direct feed from city mains require a constant flow of this increasingly scarce resource. Fountain # 4, near Inlet Bridge, is just such a fountain: Its fountain is fed directly from the mains, and overflows into the storm drains. Aside from the needless loss of water, it is not possible to maintain the pool's aquatic horticultural exhibit in the proper manner. With the constant flow-through of city water, the pool cannot be dyed or otherwise treated with chemicals, for these would be quickly diluted by constant water replacement.

Those remaining pools within NCR not equipped with recirculation systems should be identified and converted to recirculation systems.

Chemical Treatment: Maintaining excellent water quality often entails a combination of manually attending to system cleanliness and the judicious use of various chemicals to safely control nuisance life forms that are quick to establish themselves in an otherwise sterile body of water.

The control of unwanted life forms in architectural water bodies often calls for limiting their ability to grow in the system and/or destroying them. Common "invaders" of aquatic systems are filamentous algae. These algae can quickly choke a system and become an unsightly nuisance. Chemical means for controlling algal blooms include both specific (and EPA-approved) chemical algicides and aquatic dyes that diminish light penetration in the water, thus depriving algae of light essential for its growth.

Algal blooms are routinely experienced in aquatic systems that are rich in accumulated nutrients (particularly nitrogen and phosphorous). These can come from fertilizers which, if not properly administered or are in excess, may run off adjacent landscaped areas during rain storms. Nutrients may also fall out of the air on particulates, be introduced by the defecation of visiting waterfowl and other aquatic life that gets into the water, or simply be released from decaying organic debris such as leaves. Thus, when algal blooms persist, a ready remedy may be frequent flushing and dilution of affected water bodies through the introduction of fresh water. Where runoff is a main source of nutrients, a change in the fertilization program should be entertained that (1) encourages application of fertilizer into soils as opposed to top dressing--i.e., drilling or injection, that limits the amount of fertilizers used, (2) Leaves the use of slow-release fertilizers less prone to running off, (3) includes a means for diversion drainage around the water body, and (4) encourages any fertilizer application be made in the fall when the risk and concern for algal blooms is less.

Pesticides, Dyes and Other Chemical Controls: In those situations where chemical management of filamentous algae or other unwanted algal blooms is the selected option, the material to be used needs to be in harmony with other components of the pool. One of the chelated copper compounds should be opted for. These formulations help protect the copper moiety from deactivation through precipitation with calcium present in the water. Where calcium levels are determined to be high (hardness), then an organic algicide such a simazine could be considered.

Treatment should be applied only after the monitoring program indicates that the nuisance algae is in a building stage and once the water temperature reaches 60 degrees F. It is at the same time quite important not to wait too long, since once the algae has moved into an exponential growth stage it becomes that much more difficult to bring under control. In addition, die-off of extensive algal mats can easily lead to a severe drop in dissolved oxygen which would be detrimental to most aquatic organisms in the system.

It cannot be emphasized enough that the primary approach taken by the NPS should be to take the prerequisite steps to avoid blooms, rather than face situations where chemical application becomes a practical necessity. Such tactics as a flow-through water system which can be implemented when desirable to dilute the build-up of nutrients which encourage algal growth, use of dye or planting of shade trees, and aerators should all be utilized before resorting to chemical management. Often at least one complete exchange of pond water in March is sufficient to thwart the inception of an algal bloom.

As with any proposed chemical treatment, Form 10-21a needs to be completed, submitted and approved prior to application. Filling out the form requires consideration of the many factors needing attention such as the chemical itself, method of application, dosage, precautions and signing, as well as verification of application by trained or certified personnel. Contact the Regional pesticide coordinator when there is any question as to the best chemical to be used or any other question concerning the application. Monitoring must continue, following treatment, to determine efficacy and perhaps the need for further treatment.

The same general strategy should be used where planktonic algae may be considered a nuisance, particularly where clear water is the management objective. Dense growth of planktonic algae also reflects a high nutrient load. Thus, managing a pond system to avoid excessive nutrient levels must be a primary objective. Where other life forms in the pond are considered worth protecting, chemical treatment should be applied only to portions of the pond at a time to allow faunal escape from treated areas that might develop low oxygen conditions (eutrophied).

The Role of Dyes: The use of aquatic dyes which darken the water brings numerous benefits--both in terms of system aesthetics and the control of algae. Many architectural pools are light-colored structures permitting a view of the bottom. In many cases water clarity serves no aesthetic purpose, particularly when a feature of the system is to display aquatic plants such as water lilies, lotus, and other such ornamentals or exposed piping or litter shows on the bottom. In the main, a "black-water lagoon" is the preferred backdrop since it is both reflective and hides undesirable elements.

An advantage of dark water pools is the discouragement of visitors prone to wading in such pools. Through experience it has been learned that of those who willingly enter and wade, a very high percentage of these will not enter the pool if they cannot see the bottom.

Two forms of dye exist for the dying of water. Both are in concentrated powder form. One is an insoluble nigrosine dye, and the other is a soluble food coloring. The former is less expensive, but, unless rapidly recirculated, it rather quickly settles and must therefore be added more frequently to maintain desired tint densities. The latter is more expensive but may last several months rather than few weeks.
The soluble dye is available in both black and in blue. The black is so intense that the resulting effect looks unnatural, almost tar like. When only blue dye is used the water develops a swimming pool or tropical-marine hue. But this effect is short lived. The water soon changes to an ashen grey. A formulation of 9-parts of acid black dye to 1-part of blue dye is suitable for both controlling algal blooms and for imparting the most desirable aesthetic effect. One company, Atlantic Chemical Company, of Nutley, New Jersey, manufactures this dye mix.

The amount of dye used is a matter of aesthetic judgement. If darkening the water for aesthetic purposes is the requirement (and to keep visitors from seeing the bottom--and wading in the pool), the addition of the dye to the degree of obscuring the bottom is the measure to seek; gradually apply the dye until, when evenly distributed, the bottom is obscured. The net effect will be a sheet of water that looks a bit like deep north Atlantic waters. By way of reference, the amount needed to effect this aesthetic state for the Reflecting Pool, which is about two feet deep, is about 5 parts per million (5 ppm) or 18 pounds of the 9-1 mixed dye in 11 million gallons of water. Deeper pools would require less to obscure the bottom, shallower pools more. The ratio is about 1 pound of the nine-black to one-blue mix of powdered dye to 500,000 gallons of water.

The use of the dye to control algae is a function of keeping sunlight from promoting its growth. The amount of dye required to cut solar input to the water by fifty percent is almost un-noticeable, and fifty percent reduction of sunlight available to the algae is punishing to its growth. Thus, a very small amount of dye in formal fountain displays will not be obvious, but will greatly reduce the likelihood of algae thriving in such aquatic displays. The key to success is to apply the dye before the algal growth occurs near the water surface. Obviously, once the algae has surfaced, the shading effect of the dye has been largely lost.

Being a concentrated but inert dye, it should be carefully handled and applied; if spilled, the cleanup job will be prodigious. Determine the actual amount of dye that will be needed and then dissolve the powdered dye in water. The best way to apply this concentrated liquid mix is by using a pressurized tank and hose system, either of the backpack kind or a truck-mounted unit depending on the size of the pond. Extreme care should be taken to make sure the sprayer assembly is clean and free of whatever chemicals may have gone through it before. Even the latent presence of chemicals used earlier, perhaps for tree-spraying against some disease, mixed in with the dye might be very destructive. The concentrated premeasured dye solution is then sprayed over the surface of the pool to distribute it as evenly as possible. Care should be taken to avoid dripping the dye mix onto marble, masonry, etc., for the cleaning of dye-stained marble can be time-consuming. Before leaving the site it is wise to flush out the system that contained the dye. It is tenacious so several flushings will be required (putting each rinse into the pool just treated).

The Role of Ornamental Aquatic Plants: A select number of the water bodies in NCR are planted with aquatic plants for ornamental purposes. For example, Rawlins Park pools are annually planted with an assortment of exotic water lilies, while several of the ponds on Pennsylvania Avenue receive aquatic irises (and other emergent plants). In order to keep these ornamental exhibits attractive and presentable it is important that their installation be properly managed and that, once installed, they are routinely cared for during their growing season.

With few exceptions, aquatic plants for ornamental architectural water bodies should be installed in wooden box planters. Unless confined to boxes, ornamental aquatic plants may spread beyond the architectural "plan"

for the plantings, or at least make confining the plants to this plan a labor-intensive process. Bare soil on the bottom of such ponds also makes keeping the water clean and clear very difficult.

The standard planting box is made of 2-inch thick boards of treated pine (or other water-tolerant woods) to form a box two feet square by up to one foot deep (larger, four-foot square boxes are used occasionally). To strengthen the boxes they are girdled with metal strapping. Larger boxes should be avoided for, once filled with soil, they will be too heavy to be handled by staff, even though buoyed once beneath the water surface. They should be equipped with sturdy handles off their top edges to facilitate their being moved about within the pool. There are a number of plastic planting boxes now on the market intended for small tree plantings in hotel lobbies, etc. Where acceptable these can serve as lily planters and are less costly than hand-made planting boxes. Lilies are usually installed in the spring and should be planted using sandy loam soils supplemented with 20-10-10 fertilizer. Before installation, exposed soils should be covered with gravel to serve as a barrier against soil erosion which would muddy the water and to discourage waterfowl from foraging in the boxes. Hardy water lilies should be allowed to overwinter in place but the boxes should be removed every 2-3 years for thinning.

Pre-planted boxes are lowered into the water by forklifts (or on the lip of a front-end loader), or slid down wetted planks, until they are buoyed by the water and can then be moved by staff to their assigned locations in the pond. Cinderblocks or bricks may be used to shim the planting boxes off the bottom to their horticulturally prescribed elevation (normally 18-24" deep).

The management of aquatic plants in this manner offers several benefits. From an aesthetic point of view this arrangement allows the repositioning of the boxes to suit changes in horticultural configuration. Lilies, for example, may range beyond anticipated distances and may "crowd" other plantings. Being based in planting boxes it is a relatively easy chore to simply move the box involved to better accommodate the real growth pattern of the plant.

A second advantage is the ability to keep the pool relatively clean. If the soils are properly located in the boxes, and covered with sand or gravel to keep them from clouding the water column, the recirculation system's filtering system will be under less stress--resulting in a clearer, cleaner appearance of the pool (if the water is at all murky--ladened with suspended soil--even dyed water will be muddy looking).

When the pool must be drained--for repairs, cleaning, or making changes to the horticultural planting plan--the bared pool bottom is more easily cleaned by having all the planting boxes elevated above the bottom. In most cases, loose trash such as paper, beverage containers, etc., can be raked and gathered for removal before the bottom is hosed down.

The use of heavy equipment is sometimes called for in the setting up and managing of ornamental aquatic pools. Fork lift trucks and front-end loaders are a favored choice, particularly when planting boxes must be hoisted into and over the pool bottom. Care should always be taken, however, that the use of such equipment does not damage the pool or other resources. When servicing activities call for moving such equipment over adjacent grassed areas, it is well to place scrap plywood sheets down to distribute their weight and thus avoid rutting the turf. Care should also be taken not to position heavy equipment so close to the pool side that there is any risk of stressing or collapsing the poolside walls. Heavily-loaded and large trucks should never be driven immediately adjacent to masonry-sided pools!

WINTERIZATION OF CONSTRUCTED WATER BODIES

In earlier years many of our ornamental pools were drained during winter months; the planting boxes were removed to remote storage and the pool left barren for the winter. From an aesthetic point of view, this presented winter visitors to the parks with a pretty dismal visual impact. And, aside from the increased labor

involved in rousting the planting boxes, extra pool cleaning, etc., there are other drawbacks and costs associated with this practice.

Experience in the swimming pool industry has come to show that the risks of damage to pool masonry by expanding ice formation are outweighed by the high probability of stress damages caused to the same pools, if left empty during winter weather. Exposed masonry is subjected to considerable thermal shock during winter weather. Under a bright sun, in spite of ambient cold air above a pool, the masonry can well "see" a temperature variation of over 75 degrees in a typical day-night cycle. The pool bottom will seldom remain dry, and where there is the existence of a tile or layered bottom of any kind it is a common occurrence to have water that has seeped under the tiles freeze and expand--and thus dislodge the tiles. Every time a pool is emptied of its water load the masonry of the pool becomes subject to stresses caused by the sudden removal of the weight of the water it contained earlier. "Ground-heaving" effects are introduced at the same time--and, over time, the empty pool will see more of this effect as the ground itself is impacted by the thermal shocks associated with the long winter seasons' normal fluctuations in temperature, water absorption, etc. In the main, leaving such pools empty for the winter season invariably required considerable masonry repairs each spring, before they could be refilled for the warmer seasons. All of these considerations obviously represent considerable maintenance expenses.

There remains the question of protecting the pool sides from the effects of sheet-ice stress during winter weather. This happens when the surface of a large water body freezes and expands against its banks. In a rectilinear masonry pool this could be potentially destructive so this must be avoided.

Surface ice is a strong force, so long as it is unbroken. Means for insuring that water in a pool will not develop into unbroken sheet form are simply and practically managed. Swimming pool owners are instructed to float plastic beverage containers in their pools (anchored so they remain near the center of the pool) that are half full of salt water or an anti-freeze solution, so that they will remain supple during freezing weather. These "flexible" spots in the water continually fracture the ice that forms on the water surface--and rids the sheet of its ability to exert stress. Wooden logs can impart the same effect and are far more aesthetic that plastic bottles. A host of "throw-away" container candidates exist--up to drum size--that can be mustered to serve this function during brief periods when severe cold weather threatens to harm pool masonry.

Another approach is to leave any aquatic display operating during the winter. This, too, will keep a "hole" open in the ice. The ice formation "sculptures" that the fountain will create around it will be ever-changing and will add a new visual-quality dimension to the facility.

Damage to the bottom of the pool can happen in summer weather as well--particularly during times when the pool must be drained for cleaning. Ground "heaving" can be experienced anytime the weight of the water is taken off the pool bottom. The riskiest time to drain any pool is during the heat of hot summer days. If the pool bottom is exposed directly to noon-time solar radiation, it can expand and even if equipped with expansion joints, they may not be adequate to keep the masonry from becoming stressed--and cracking. When a pool must be drained down in hot weather a few inches of water should be left on the pool bottom--to soak up and somewhat abate the heat of the sun. Pool purges should be very carefully planned so that the pool is empty for as short a time as possible--and preferably during cloudy weather.

POOL MANAGEMENT BY HARNESSING NATURAL FORCES

In SYNTHETIC MANAGEMENT OF ARCHITECTURAL POOLS AND FOUNTAIN SYSTEMS of this chapter, discussion was devoted to the physical factors of many of the NCR water bodies including their management by basic cleaning and chemical means. In recent years NCR has developed an alternative set of procedures for the management of water bodies where the management goal is more towards enhancing an informal setting that will attract wildlife and can accommodate inclusion of a diverse set of flora and fauna. These procedures key on the exploitation of natural/ecological mechanisms of management often associated with wetland ecosystems.

In the late '60's difficult water quality maintenance problems occurred in Bolivar Pond, at the south entrance of the Department of Interior's main building, that made the pool unsightly and expensive to maintain. NCR installed specialized boxed plantings and other life forms in order to simulate the makeup of a natural wetland. Aside from the appropriateness of such a "natural" amenity immediately associated with the Department of Interior and its many missions, quite real and very extensive cost benefits resulted from the trial. In previous years, this pond was almost continually littered by some who visited or passed the site and it was frequently choked with filamentous algae. Records revealed that the pool required draining and cleaning a number of times during warm weather periods (it was left empty during the winter) and even with constant attention the facility seldom appeared to be maintained.

With the installation of the wetland in Bolivar Pond, algal blooms became few and visitation to the park radically increased. People found it pleasant to sit by the pool during their lunch breaks and visitors observed and photographed the wildlife that also found its way to the pool). The former "trashing" of the pool largely ceased, probably because now that the site was well-visited, few would risk the rebuke of witnesses to any littering. The cost benefits that were quickly realized and recognized there made it incumbent on us to determine why these benefits accrued and to explore ways that these same benefits could be gained elsewhere.

Constitution Gardens Lake was built several years later. During its early period, the large expanse of shallow water was frequently fouled by filamentous algae; frequent drainings were required to remove this detritus. In this case costs often exceeded $20,000 for each purge--often several in a season.

An ecosystem similar to that put in Bolivar Pond was installed in Constitution Gardens Lake in the late '70's. It differed from the Bolivar system only in that its host of aquatic plantlife consisted solely of submerged aquatic vegetation. Constitution Gardens Lake was designed to serve as an architectural reflecting surface and emergent plantlife would disturb this function. The planting plan does support water lily plantings, however, in the channel between the north shore and the Signers Memorial island.

Fifty large plant boxes, 1 X 4 feet in dimension, were installed in the westerly end of the lake and filled with a mix of underwater vegetation obtained from the Kenilworth Aquatic Gardens. The purpose was to establish habitat for a variety of aquatic life--from single celled organisms to snails, and other minute life--so that these elements of the basic aquatic food chain could thrive and reproduce.

It had been learned from the Bolivar Pond experience that the control of filamentous algae, the greatest of the "threats" to pool management, was more assured if there was a broad spectrum of competitive food chain elements in the water of a pond.

To speed up the establishment of those elements of the food chain that were predators of the algae, several tank loads of healthy pond, or swamp-bottom silt slurry were collected at the Kenilworth Aquatic Gardens and pumped into Constitution Gardens Lake. On several occasions this was done early into an onset of filamentous algal bloom and within a relatively short time the bloom was arrested. While this natural control is not absolute--occasional blooms will occur during periods of prolonged hot sunny summer weather--the control does seem to reduce the intensity of such blooms. The mechanics of executing a silt slurry transfer call for the use of a truck-mounted pumping system of the kind used for emptying public temporary toilets (such as those used for occasional high-visitation public events). After steam cleaning (for public health reasons) this truck takes on a full load of water and proceeds to the Kenilworth Aquatic Gardens. When a suitable pond is selected, the tank of water is vented down into the pond through a nozzled hose and thus stirs up the silt bottom to create a slurry rich in plankton. When the truck is empty the system is reversed and the hose now sucks a load of the slurry into the tank. Screens have to be used, instead of the nozzle--when taking aboard the silt--so that leaves and other debris are not sucked into the pump plumbing.

The load of silt slurry is then pumped into the lake and distributed as well as possible. In larger water bodies the truck should be driven slowly around the shore while the slurry flows into the water. Several truck loads (compassing an eight-hour service day) are a good investment to insure the more rapid impact of this treatment. The process described serves to inoculate the lake with a rich source of zooplankton some of which are predators on algae. While this has not been quantified it is known that naturally balanced ponds are a rich source of the life forms involved.

The bottom line is that the process works as an algal control method and is in keeping with the Integrated Pest Management process practiced by the Service, thus avoiding reliance on chemical means for algal control.

The success of this natural-system approach to managing water quality is reflected in a gross reduction in maintenance costs. An added bonus is the remarkable vista that confronts the visitor to the lake that of a natural area replete with groups of healthy waterfowl and surrounded by a park setting that is quite unique to the center of most urban areas. It should be remembered, however, that such a living system will age and within ten years the system may need renewal in part or en toto.

The Makeup of a "Tailored" Ecosystem: The components of a simulated ecosystem are not much different from those used in architectural pools planted with ornamental aquatic plants. Boxes of soil are put up in much the same manner. It is the choice of plantlife and selected aquatic animal and fish life that makes the difference. In the main the installed system includes a broad spectrum of the kind of aquatic plantlife--both submerged, and emergent growth--and such other life as snails, amphibians (frogs, etc.) and certain of the fish life that is found in native wetlands in nearby natural areas. These sites, in fact, often become the source of the plant materials selected.

Animal and Fish Life: Many life forms that can migrate on their own will find their way to ponds that begin to look like--behave like--a natural ecosystem. When Bolivar Pond was first installed, a variety of flowering and floating vegetation was included. Such denizens of natural aquatic systems as dragonflies and damselflies--and even honey bees--found their way there to be nurtured by the many forms of nourishment and other natural benefits the newly-planted ecosystem now offered.

Fish can be included but care should be taken not to include largemouth fish such as bass or bluegills--unless you do not care what happens to other life in the pond that is likely to be eaten. Except for specific ornamental fish (e.g., Japanese Koi) only small fish, such as the gambusia (mosquito fish) should be included--these being a valuable, natural mosquito control mechanism since it feeds upon mosquito larvae.

Turtles make fine show pieces, provided an old log can be installed for them to bask on. Basking is not just a pleasure--it is a requirement for turtles to get dry in order to control parasites and fungi that get on their skin. Avoid aggressive turtles (such as snappers) for they will attack other life in the pool and if large enough can seriously injure someone. Sliders (*Pseudemys* sp.) make a stunning centerpiece for a pool but should be avoided if such architectural ornamentals as lilies are featured in the pond. These turtles will quickly devour all such plants. In most cases a few painted turtles (*Chrysemys* sp.) are a safer choice for, while they may sample such plants, they will not severely attack plants or other fish since their main diet is composed of smaller life including insects. They also thrive on such fish-hatchery food as "Trout Chow" (in the larger pellet form).

The Kinds of Aquatic Plants Required: There are several reasons for utilizing a diversity of wetland plants as a portion of the pond management scheme. Certainly there are aesthetic benefits but perhaps more importantly plants must be a component of any balanced ecosystem. Plant groups may include submersed aquatic plants, water lily forms, emergent vegetation or pond side species. All of these vegetation groups provide a measure of habitat, food, shelter, oxygen and nutrient sorption that help promote the well-being of the other components of the balanced pond ecosystem. Submersed aquatic vegetation (SAV) in particular will augment the potential for plankton including zooplankton species which are predatory on some of the algal species. The SAV can be expected to compete for available nutrients to help suppress excessive algal growth when nutrients are not

limiting. Of course when the SAV declines in the fall some of the nutrients are released back into the water column or sediments. Since additional nutrients are released from decaying tree leaves in the early spring that is a prime time to assure a turnover of the pond water to help dilute out the released nutrients. Moreover, in early spring some of the predatory organisms on algae have not yet built up in numbers which further permits the capacity for a "spring bloom" of algae. Submerged aquatic vegetation species should be selected so as to provide extensive growth throughout the growing season. Our experience in Washington, D.C. suggests that species such as the potomogetons, millfoil and ceratophyllum grow well enough during the spring and fall but sag noticeably during the warm water days of summer, particularly in the artificial ponds to which little new water is added. Thus hydrilla, which has been noted to be a strong summer performer (to the degree that it often poses navigational hazards in nearby rivers) as well as vallisneria and heteranthera, should be used to maintain a growing season of long vigorous growth of SAV. Thus a mix of cool water and warm water species should be used.

Depending on pond design and materials most plantings in the water are easily managed or contained by planting in some sort of container or depressions. This permits growth to the extent of design. Some species will surely break out and grow in detritus or soil outside the planters. Where such growth is considered a nuisance mechanical removal is to be recommended. Emergent vegetation should include seasonal plants such as marsh marigold and golden club for the spring; pickerel weed, iris, arum, sagittaria and water lilies for the summer; and marsh mallow for the fall. A more extensive list of emergent plants, ferns and shrubs is included in Tables I - III.

SUMMARY AND CONCLUSIONS

Pond management strategies need to be matched with the purposes and nature of the pool. The purely architectural and formal pools call for mostly synthetic type treatments or none at all while informal pools meant to encourage plantscaping and wildlife are best managed through a balanced ecosystem approach. Regardless of the methodologies or mix of methodologies utilized careful monitoring must be performed to keep a pulse on the "active patterns" in the pond. Monitoring includes observations, field notes and some technical measurements of such factors as dissolved oxygen, pH, hardness and nutrient levels. Ponds are dynamic systems with changing equilibria among its components. Due to unnatural aspects of artificial ponds such as exposure, limit of fresh water inputs, constructed sides and bottom, location, etc., they cannot be expected to behave as they might otherwise, thus they must be managed to help keep them within an acceptable pattern. Many aspects of pond management may be done according to predetermined tactics and timing but with the ecosystem management strategy there will be times when good judgement and short term decisions will have to be made. Natural patterns do not always coincide with text book descriptions, particularly since they're linked to variable weather conditions.

PLANTS FOR AQUATIC USE

Table I. Ferns

Species:	Height Inches
Dryopteris cristata -- Crested shield fern	24
Dryopteris thelypteris -- Marsh fern	36
Osmunda cinnamomea -- Cinnamon fern	16
Osmunda regalis -- Royal fern	32
Osmunda claytoniana - Interrupted fern	30
Onoclea sensifiles -- Sensitive fern	24

Table II. Shrubs

Species:

Clethra alnifolia - Sweetpepperbush
Cephelanthus occidentalis -- Button bush
Corylus avellana contorta -- Harry Lauder's Walking Stick-Hazelnut
Viburnum trilobum -- American cranberry bush
Vibernum dentatum -- Arrowwood
Myrica pennsylvanica -- Bayberry
Hippohae rhamnoides -- Sea buckthorn
Hamamelis "Arnold Promise" -- Arnold Promise witch hazel
Alnus rugosa -- Speckled alder

Table III. Emergent Vegetation for Ornamental Ponds

Emergent Species	Major Season(s)* of Interest	Foliage** Character	Height Inches
Filipendula almeria -- European meadowsweet	Sp,Su	2	40
Lythrum salicaria -- Purple loosetrife	Su,F	2	40
Equisetum hyemale -- Scouring rush	Sp,Su,F	3	36
Lobelia cardinalis -- Cardinal flower	Su,F	2	36
Lobelia siphilitica -- Blue lobelia	Su,F	2	36
Menyanthus trifoliata -- Bog bean	Sp,Su	2	10
Myosotis scorpiodes -- Water for-get-me-not	Sp,Su	2	10
Peltiphylum peltatum -- Umbrella plant	Su,F	3	36
Pestasites japonicus -- Japanese butterbur	Su,F	3	48
Rogersia pinnata	Su,F	3	36
Rogersia tabularis	Su,F	3	36
Calla palustris -- Water arum	Sp,Su,F	2	24
Iris kaempferi -- Japonese iris	Su	1	20
Pontideria cordata -- Pickerelweed	Su,F	2	24
Peltandra virginica -- Arrow arum	Su,F	2	48
Hibiscus moscheutos -- Rose mallow	Su	2	48
Saururus cernuus -- Lizard's tail	Su	2	30
Zizania aquatica -- Wild rice	Su,F	1	60
Symplocarpus foetidus -- Skunk cabbage	Sp	3	20
Orontium aquaticum -- Golden club	Sp,Su	3	24
Acorus calamus -- Sweet flag	Sp,Su	1	24
Eleocharis obtusa and spp. -- spike rush	Sp,Su,F	1	18
Sagittaria latifolia and spp. -- Wapato duck-potato	Su	2	30
Alisma subcordatum -- Common waterplantain	Su	2	24
Typha angustifolia -- Narrow leaved cattail	Su,F	1	48
Typha minima -- Dwarf cattail	Su,F	1	30
Typha latifolia var. variegata	Su,F	1	36
Sparganium americanum -- American burreed	Su	1	36
Ligularia stenocephaea and spp. -- The Rocket	Su	3	48
Butomus umbellatus -- Flowering rush	Su	1	36
Juncus effusus -- Soft rush	Su	1	30
Juncus effusus spiralis -- Corkscrew rush	Su,F	3	30
Scirpus fluviatilis -- Common bullrush	Su	1	36
Scirpus americanus -- Common threesquare	Su	1	36
Scirpus zebrinus -- Zebra rush	Su,F	1	36
Scirpus albescens -- White rush	Su,F	1	36
Caltha palustris -- Marsh marrigold	Sp	2	12
Iris pseudacoris -- Yellow flag	Sp,Su	1	36
Iris laevigata -- Water iris	Su	1	20
Usticia americana -- Water willow	Su,F	2	24

*Sp = Spring
Su = Summer
F = Fall

**Narrow leafed = 1
Round leafed = 2
Special interest = 3

SPRINKLER REPAIR AND MAINTENANCE

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An irrigation system is only as good as its sprinkler heads. A great design won't irrigate properly if the nozzles are clogged or the risers don't pop up. To help avoid problems, put your sprinkler heads on a maintenance schedule.

Weekly system inspections are the cornerstone of your preventive maintenance program. Check the sprinklers when they're in operation to make sure all are operating correctly. Look for vandalism or mower damage. The heads should be perpendicular to the ground on level areas and perpendicular to the horizon on mild slopes and rolling terrain.

Sometimes your mower will hit a sprinkler and knock it out of alignment, distorting the sprinkler pattern. To realign the head, pull it back into a perpendicular position and tap the soil around it. Firmly compacted soil will help hold the sprinkler in place. The quicker you replace or fix damaged sprinkler heads, the less likely you are to lose turf.

If your water supply is hard or contaminated with sand, check your nozzles frequently for mineral deposits and abrasions. The abrasive action of the sand increases the size of the nozzle opening, which decreases the system's operating pressure. The increased nozzle opening also reduces the sprinkler's radius. Mineral buildup has the opposite effect. The buildup clogs the nozzle, which increases the pressure. It also increases the spray pattern but not necessarily uniformly.

Replace worn nozzles and clean off any buildup. Plastic nozzles stand up better to buildup and abrasion.

Cleaning Nozzles

If you notice a difference in the amount of water spraying from your sprinkler heads, chances are they need cleaning. All nozzles will need the debris cleared on a regular basis.

Before you disassemble spray heads or some rotors, try to clear the debris by removing the nozzle and flushing. Use caution when doing this because you could be injured by the high water pressure at the nozzle. Never stand or lean directly over the sprinkler when you're manually or automatically operating it.

Turn the sprinkler on and push the cap and riser up and down several times to clear debris wedged between the riser and the sprinkler body. Turn the sprinkler on and off again to see if the debris has cleared.

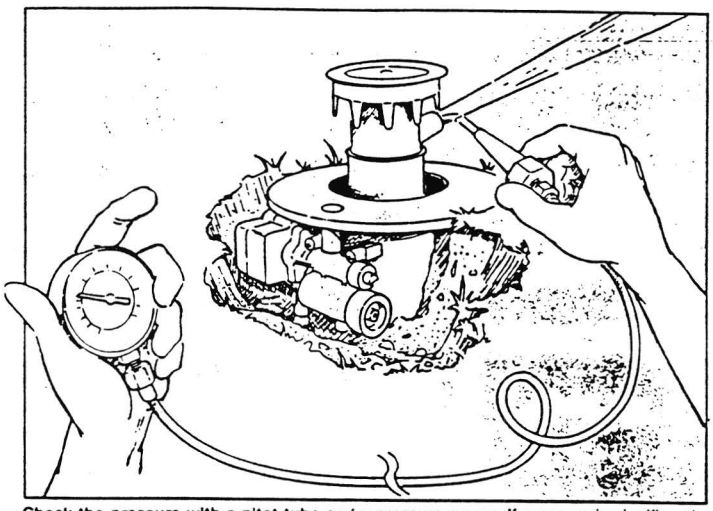
If not, follow directions in your operator's manual to take apart the sprinkler. Clean the nozzle or replace if necessary. Use a plastic cleaning tool on plastic nozzles so you don't score the opening. Be sure to align the nozzle as the manufacturer recommends and check the coverage arc. After you reassemble the sprinkler, repeat the flushing to be sure all the debris is removed.

Checking the Pressure

If cleaning the nozzle didn't solve your problem, check the pressure. One telltale sign of reduced pressure is a doughnut-shaped dry area. A drop in supply pressure is one possible cause.

To check pressure at the nozzle, you'll need a pitot tube and a pressure gauge. Stand to the side of the sprinkler so you won't come in contact with the spray. Follow the manufacturer's instructions to turn on the water at the

sprinkler. Hold the pitot tube in the main nozzle flow. The water pressure will register on your pressure gauge. Expect to get wet when you do this.



Check the pressure with a pitot tube and a pressure gauge. If pressure is significantly reduced or increased, take corrective measures.

If your sprinkler has an adjustable pressure regulator, adjust it to compensate for the increase or decrease in the system pressure. Recheck the pressure with the pitot tube.

If your system doesn't have adjustable sprinklers, review the pressure difference. There is not a lot you can do about a significant pressure decrease in an installed system except to add a booster pump. If the pressure drops by 15 to 20 psi, consider reducing the nozzle size. This will increase the pressure, but your sprinkler head patterns may not be as effective as before. If you notice a difference in coverage, you may have to increase your run time.

For pressure increases of more than 20 psi, consider installing pressure reducing valves. These valves maintain a constant pressure to the sprinkler nozzle. On adjustable pressure reducing valves, the factory will pre-set a pressure range, but you can easily alter this to fit your site.

Other problems

Many of the problems you'll encounter from time to time on large area sprinklers you can fix with a little practice. Ask your distributer or sprinkler head manufacturer for a service manual that covers valve or gear troubleshooting. Many distributors run training seminars that walk you through repairs.

One of the key things to remember when working on large-area sprinklers is to shut off the water supply upstream of the valve you are working on. You can trace many valve problems to dirt or debris clogs, so cleaning is a good place to start. If you find damage to the valve seat, seal or diaphragm, replace that item. Carefully reassemble the sprinkler head, making sure everything stays clean when you reassemble it. Check for leaks when you're done.

Technical and illustration credit: The Toro Company-Irrigation Division

Larry Keesen,
Larry Keesen Ltd.,
Denver, Colo.

SPECIFICATIONS

GENERAL

These are sample specifications for your guidance in preparing specifications unique for your park's needs. There are places where alternates are given, these are indicated by **OR**, [alternate 1][alternate 2] or xx. These are not alternates to be given to a contractor or supplier, but are for the park to select the option or quantity which most nearly meets their needs. Other instructions to the specification writer are high-lighted with triple asterisks (***....***.) More complex projects are given in the Construction Specifications Institute (CSI) format. Simpler projects and supplies are not in a the CSI format.

The CSI format attempts to achieve uniformity in the organization or layout of the contract documents. Each section has a 5-digit number; the first 2 identify the Division, the third identifies the Broadscope Section and the last 2 identify the feature. For instance, tree planting is always in Section 02950; 02 is Sitework, 9 is Landscaping, 50 is Trees, Shrubs and Groundcovers. The last digit can be other than 0 if the project is of such complexity that it is desirable to have different sections to deal with different type of trees or to separate trees from groundcovers. Thus trees would be Section 02950, shrubs might be 02951, and groundcovers Section 02952.

Section 02200 addresses Earthwork and might be necessary as a part of the specifications. Division 1 addresses General Requirements, the "boiler plate"; consult your contract specialist for the applicability of this. The NCR, Division of Contracting has prepared a set of Standard Provisions tailored for NCR parks.

The Denver Service Center has prepared the Guide for Specifiers, which provides guidance as to style and content, has a list of the CSI section titles and numbers. This is available through the Division of Contracting. The Office of Design Services has draft and sample specifications using the CSI format.

FERTILIZER

Fertilizers or fertilizer materials shall be standard commercial products and conform to all State and Federal laws. They shall be uniform in composition, dry and free flowing, suitable for application with standard equipment. Any fertilizer or fertilizer material which has become wet, caked or otherwise damaged, making it unsuitable for use, will not be accepted. It shall be furnished in sealed standard containers.

Each fertilizer or fertilizer material shall be granulated in accordance with Term T-16, Association of American Plant Food Control Officials.

Fertilizer or fertilizer materials shall be selected and blended so that the finished product shall contain not less than xx percent nitrogen, xx percent available P_2O_5, and xx percent soluble K_2O.
The Contracting Officer may sample, inspect, make analyses of and test fertilizers and fertilizer materials purchased.

Note: Percentages of the nutrients must be specified using information from soil tests, plant requirements, past practices, purpose of fertilizer and other factors.

When special conditions warrant, sources of nutrients may be specified.

FERTILIZER, FURNISH AND SPREAD

SP-1: SCOPE

This work includes furnishing and applying fertilizer to various areas of National Capital Region in accordance with these specifications.

SP-2: MATERIALS

Fertilizers or fertilizer materials shall be standard commercial products and conform to all State and Federal laws. They shall be uniform in composition, dry and free flowing, suitable for application with approved equipment. Any fertilizer or fertilizer material which becomes caked or otherwise damaged, making it unsuitable for use, will not be accepted.

Each fertilizer or fertilizer material shall be granulated in accordance with Term T-16, Association of American Plant Food Control Officials.

Documentation and certification indicating the analysis and application rates shall be submitted to the Contracting Officer for approval within 5 days of receipt of Notice of Award.

SP-3: APPLICATION

Fertilizer or fertilizer materials shall be selected, blended and applied so that not less than 50 pounds of nitrogen, xx pounds of available P_2O_5, and xx pounds of soluble K_2O will be applied per acre.

No application will be made when, in the opinion of the Contracting Officer, the soil or grass is so wet that application will be detrimental to soil, grass, or other feature.

Within 5 days of receipt of Notice of Award, the Contractor shall establish contact with each of the Project Supervisors listed in the Delivery Schedule so that mutually agreeable application times within the limits of the

Delivery Schedule can be established, provided that no less than 6 weeks are scheduled between multiple applications to the same area.

Application may be either by truck with a spinner spreader or by turf type tractor with either a mounted or trailer spinner spreader.

SP-4 INSPECTION, SAMPLING, ANALYSIS

The Contracting Officer may sample, inspect, make analyses of and test fertilizers and fertilizer materials to be purchased and applied.

SP-5 MEASUREMENT AND PAYMENT

Measurement shall be based on the number of acres of ground surface covered by fertilizer at the specified rate, completed and accepted. Measured quantities shall be verified by certified weight tickets and appropriate conversion calculations documenting coverage at the specified rate of application.

The accepted quantities of fertilizer will be paid for at the contract unit price per acre which payment shall be full compensation for furnishing and placing all materials, labor, equipment and necessary incidentals.

Note: Percentages of the nutrients must be specified using information from soil tests, plant requirements, past practices, purpose of fertilizer and other factors.

When special conditions warrant, sources of nutrients may be specified.

LIME

Lime shall be commercial pulverized limestone and conform to all applicable state and Federal laws and to Definition C-6 of the American Association of Plant Food Control Officials. The calcium carbonate equivalent shall not be less than 90 percent.

OR

Lime shall be commercial pulverized dolomitic limestone and conform to all applicable state and Federal laws and to Definitions C-3 and C-6 of the American Association of Plant Food Control Officials. The calcium carbonate equivalent shall not be less than 90 percent.

include if dust will be a problem

The lime shall contain approximately 5 percent water to reduce dust.

OR

The limestone shall be pelletized such as Ampel or approved equal.

Lime which has become wet, caked or otherwise damaged in transit or storage will not be accepted. It shall be furnished in sealed standard containers.

LIME, FURNISH AND SPREAD

SP-1 SCOPE:

This work includes furnishing and applying lime to various areas of National Capital Region as called for by the authorized representative of the respective park or unit in accordance with these specifications.

SP-2 MATERIAL:

Lime shall be commercial pulverized limestone and conform to all applicable state and Federal laws and to Definition C-6 of the American Association of Plant Food Control Officials. The calcium carbonate equivalent shall not be less than 90 percent.

OR

Lime shall be commercial pulverized dolomitic limestone and conform to all applicable state and Federal laws and to Definitions C-3 and C-6 of the American Association of Plant Food Control Officials. The calcium carbonate equivalent shall not be less than 90 percent.

include if dust will be a problem

The lime shall contain approximately 5 percent water to reduce dust.

OR

The limestone shall be pelletized such as Ampel or approved equal.

SP-3 APPLICATION:

Lime shall be applied at 2,000 pounds per acre. Application shall be uniform with approved equipment designed for the purpose. No application shall be made when, in the opinion of the Contracting Officer, the soil or grass is so wet that application will be detrimental to the turf or soil.

Application shall be made within 15 calendar days of the request by the responsible park official.

SP-4 MEASUREMENT AND PAYMENT:

The accepted quantities of lime will be paid for at the contract unit price per ton, to the nearest tenth of a ton, which payment shall be full compensation for all supplies, materials, labor, equipment and necessary incidentals to apply the lime.

Measurement shall be based on the number tons of lime delivered, applied and accepted. Measured quantities shall be documented by certified weight tickets showing gross, tare, and net weights, park and area where applied, appropriate Purchase Order Number, and the legible signature or printed name and signature of the authorized receiver of each load.

GRASS SEED

All seed shall be labeled in accordance with all State and Federal laws in effect on the date of the invitation for bid. All seed shall be certified by the appropriate State certifying agency using the standards of the International Crop Improvement Association. Mixtures and blends shall only be formulated under the supervision of the appropriate local seed certifying agency, and shall carry their seal.

The seed shall also meet the following requirements for purity, germination, other crop and weed content:

	minimum purity	minimum germination	maximum other crop	maximum weed
Kentucky bluegrass	98	85	0.25	0.20
perennial ryegrass	98	90	0.50	0.35
tall fescue	98	85	0.50	0.25
creeping red fescue	98	85	0.25	0.20
bentgrass (Penncross)	96	80	2.00	0.20
bentgrass (Penneagle)	98	85	0.50	0.10

"Other crop" shall not include ryegrass, *Poa trivialis*, timothy, bentgrass, Canada bluegrass, or tall fescue; except that seed of perennial ryegrass may contain up to 3% ryegrass other than the named variety.

The seed shall be free of dock, cheat, chess, chickweed, plantain, crabgrass, bermudagrass and black medic.

Purchases of perennial ryegrass shall be tested for fluorescence and not accepted if fluorescence exceeds three (3) percent.

Seed which has become wet, moldy, or otherwise damaged in transit or storage will not be accepted. It shall be furnished in sealed standard containers.

*To be accompanied by a requisition (DI-1) or other document specifying the variety, blend, or mixture required. This should be done in consultation with the Management Agronomist.

CERTIFIED BLUEGRASS SOD

Certified Kentucky bluegrass sod: Kentucky bluegrass sod shall be living "Certified Sod" or "Certified Turf."

It shall be grown from a blend Kentucky bluegrass seed which meets the requirements for certification. Certification shall be by the State Certifying Agency such as the Maryland Department of Agriculture, the Virginia Crop Improvement Association or the appropriate agency of another state.

OR

It shall be grown from a blend, which meets the requirements for certification, of not less than 30% of one of the following Columbia, Enmundi, Escort, Monopoly, Victa or Wabash, and at least two other varieties recommended by the Maryland-Virginia Turfgrass Cultivar Recommendations Work Group. No more than 35% or less than 10% of the mixture may be any one variety. Certification shall be by the State Certifying Agency such as the Maryland Department of Agriculture, the Virginia Crop Improvement Association or the appropriate agency of another state.

Each load of "Certified sod" or "Certified turf" shall be accompanied by, in the same vehicle, an official certification label and that label must be attached to a dated invoice, bill of lading or labeling information document.

The sod shall be machine cut at a uniform soil thickness of 3/4 inch, plus or minus 1/4 inch, at the time of cutting; measurement shall exclude top growth and thatch. Individual pieces shall be cut to the supplier's standard width and length; width shall be not less than 12 inches and length such that each piece is 1/2 square yard or a multiple thereof. Maximum allowable deviation from standard width shall be 5 percent. Broken pieces and torn or uneven ends will not be accepted.

Standard size pieces of sod shall be strong enough to support their own weight and retain their size and shape when suspended vertically from a firm grasp on the upper 10 percent of the piece.
Sod shall be harvested and delivered within a period of 24 hours.

If the park has preference for rolled
or folded strips, a statement to that
effect should be included.

CERTIFIED TALL FESCUE SOD

Certified Tall Fescue Sod: Tall fescue sod shall be living "Certified Sod" or "Certified Turf". It shall be grown from a mixture of one or more varieties of tall fescue[1] and Kentucky bluegrass seed which meets the requirements for certification. Certification shall be by the State Certifying Agency such as the Maryland Department of Agriculture, the Virginia Crop Improvement Association or the appropriate agency of another state.

Each load of "Certified sod" or "Certified turf" shall be accompanied by, in the same vehicle, an official certification label, and that label must be attached to a dated invoice, bill of lading or labeling information document.

The sod shall be machine cut at a uniform soil thickness of 3/4 inch, plus or minus 1/4 inch at the time of cutting; measurement shall exclude top growth and thatch. Individual pieces shall be cut to the supplier's standard width and length; width shall be not less than 12 inches and length such that each is 1/2 square yard or a multiple thereof. Maximum allowable deviation from standard width shall be 5%. Broken pieces and torn or uneven ends will not be accepted[2].

Standard size pieces of sod shall be strong enough to support their own weight and retain their size and shape when suspended vertically from a firm grasp on the upper 10% of the pieces.

Sod shall be harvested and delivered within a period of 24 hours.

***[1]. If the park has a preference for certain varieties of tall fescue, they should be named here. No one variety should be less than 10 percent of the total mixture. ***

[2]. If the park has preference for rolled or folded strips, a statement to that effect should be included.

TOPSOIL

Topsoil shall be the **natural**, original surface soil, shall be in a friable condition and shall contain less than 3 percent subsoil, hardpan material, stones and clods larger than 1/2 inch in diameter. It shall also be free of sticks, tree or shrub roots, debris, and other material undesirable for plant growth. The area from which the topsoil will be obtained and the topsoil shall be free of undesirable plants such as, but not limited to, bermudagrass, nut sedge, mugwort or noxious weeds as set forth in the Federal Seed Act.

The topsoil shall contain at least 1.75 percent organic matter. It shall be a sandy loam consisting of at least 5 but not more than 20 percent clay, at least 10 but not more than 40 percent silt, and not less than 45 nor more than 80 percent sand. It shall have a pH between 6.0 - 7.0. Soluble salts shall not exceed 500 ppm. Soil Fertility shall be "High" in natural nutrients based on the coordinated ratings in pounds per acre as established by the National Soil and Fertilizer Research Committee.

Topsoil which has been manufactured by blending materials which individually do not meet the requirements of this specification will not be accepted, even though the resulting blend meets the organic matter, mechanical analysis, pH and soluble salts requirements. Agricultural limestone at not more than 5 pounds per cubic yard of topsoil may be used to adjust the pH, provided it is well mixed in a manner which does not destroy the structure of the soil.

The soil will also be subject to inspection and rejection at the source and at the time of delivery. The Contractor shall be required to remove any soil which is delivered without the consent of the Contracting Officer and which does not comply with these specifications.

Within 5 calendar days subsequent to award of a contract, the Contractor shall furnish a certified report from the Soil Testing Laboratory, University of Maryland or other approved soil testing facility giving the soil source, texture, pH, magnesium, phosphate, potash, organic matter, soluble salt, and mechanical analysis of the topsoil.

Note to parks: Where possible existing topsoil should be salvaged and reused.

SEASONAL PLANTS

General

The plants to be purchased under this invitation will be planted at selected locations in the National Capital Area, Washington, DC. The floral displays are designed as visual focal points in the park areas. Consequently, the plant material shall be of the highest horticultural grade and quality. Plants shall be true to name, size, blossom color, and of uniform size by variety. The Washington, DC area is subject to sudden temperature changes; therefore, the material shall be hardened off by being subjected to outdoor conditions prior to delivery.

Plants shall not be stretched but compact and uniform in growth, showing healthy leaf color. Pinching may be required to produce a full and compact plant but shall not be performed after May 1. Plants shall be grown in sterilized medium of at least 1/4 soil. Upon delivery all root systems shall be moist. All appropriate horticultural techniques shall be used including the use of sterile equipment and soil.

The following size pots and/or cell paks are required for items listed in Schedules I through IV. All plants shall be spaced in greenhouses so as to allow proper air and light for good development. Label each carton, flat or tray as to type and variety of material.

P = Individual Pots C = Cell pak

Plant	Treat in Following Manner	Pot Size
Ageratum	B-9	C 24/tray
Alyssum		C 24/tray
Amaranthus		P 4"
Aster		C 24/tray
Balsam		P 3"
Basil	Pinch	C 24/tray
Begonia		P 3"
Caladium		P 4"
Canna		P 5" (standard 2-3 stalks per pot at a time of delivery. Potting medium must contain at least 30% sterilized soil).
Carnation		C 32/tray
Cleome		P 4 1/2"

Plant	Treat in Following Manner	Pot Size
Celosia	Pinch	C 24/tray
Chrysanthemum	Pinch	P 7"
Cineraria		P 3"
Coleus	Pinch	C 24/tray
Cosmos	Pinch	C 24/tray
Dahlia	Pinch	P 4" (standard deep pot)
Daisy		P 4"
Dianthus		C 32/tray
Dusty Miller, Senicio Leucostachy (cuttings)	Pinch	P 3"
Dusty Miller, all others		P 3"
Flowering Cabbage		P 5"
Flowering Kale		P 5"
Gazania		P 4"
Geranium (seed)		P 4"
Geranium (cuttings)		P 4 1/2"
Geranium, Smash Hit Salmon	P 4 1/2"	
Gerbera		P 3"
Hypoestes		P 4"
Iberis sempervirens		C 18/tray
Impatiens	Pinch or B-9	P 3"
Larkspur	Pinch or B-9	P 3"
Lobelia		C 24/tray
Marigold, Dwarf (small flower 2" or less)	C 24/tray	

Plant	Treat in Following Manner	Pot Size
Marigold, all others		C 18/tray
Nasturtium		P 3"
Nicotiana		C 18/tray
Ornamental Eggplant		P 4"
Peppers		P 3"
Petunia	Pinch or B-9	P 3"
Phlox		C 18/tray
Portulaca		C 32/tray
Pyrethrum		P 4"
Salvia, Victoria		P 4"
Salvia, all other		C 18/tray
Sanvitalia procumbens	Pinch	P 3"
Snapdragon	Pinch	P 3"
Strawflower		C 18/tray
Sweet William	Pinch	P 3"
Verbena		P 3"
Vinca		C 24/tray
Viola		P 3"
Zinnia	Pinch	P 3"

SPECIAL GROWING CONDITIONS FOR GERANIUMS FROM SEEDS

Sow all geranium seeds before January 1, and all other seeds before February 1, thereafter transplant into no less than 4" pots as soon as possible. Apply "Cyocel" three to five weeks after transplanting, when leaves have reached half-dollar size. Transplant into no less than 4" pots in advance of delivery to permit proper root development. Caution shall be taken to prevent stretching.

SPECIAL GROWING CONDITIONS FOR GERANIUMS FROM CUTTINGS

Copies of Certification of Cultural Virus Indexed (CVI) Plant Material shall be made available to the Government upon request.

All Geranium plants must be grown from culture virus indexed cuttings or cuttings produced from CVI stock plants. Rooted cuttings shall be potted in 4 1/2 inch pots by March 15.

Plants shall not be leggy, but compact in growth with good color in leaf and flower. Plants shall be properly spaced, sprayed and fed regularly through growing period and up to time of delivery. All plants shall be free of insects, nematodes and all diseases. Treat plants with preventative fungicidal drench at least once before May 1.

SPECIAL GROWING CONDITIONS FOR PERENNIALS

Perennials shall be winter grown and delivered in no less than 4" pots.

SPECIAL GROWING CONDITIONS FOR DUSTY MILLER

Dusty Miller Senicio Leucostachy shall be grown from cuttings only and shall be pinched a minimum of one time before delivery.

SPECIAL GROWING CONDITIONS FOR GARDEN-HARDY MUMS

The garden-hardy mums shall be delivered in Zarn #400 pots or equal and have been grown in sterilized medium containing at least two-thirds soil. Plants shall be well branched and budded and field grown.

Rooted cuttings shall be potted by May 15. Plants must be in specified growing containers by June 20. First pinch will be approximately 15 to 20 days after cuttings have been potted. Last pinch will be no later than July 31. All plants shall be pinched a minimum of three times.

Plants shall not be leggy, but compact in growth, and shall be compact in growth and shall be dark green and showing good uniform bud color at delivery time. Plants shall be properly spaced, sprayed and fed regularly throughout growing period up to delivery time. All plants shall be free of insects, nematodes and all diseases. Spray plants with B-9 growth regulator at the request of Contracting Officer's representative.

INSPECTION

Review of the progress of the plant material will be made at the growing site. A final inspection for shipment will be made on or about May 1. Final inspection for acceptance will be made at delivery site(s) in accordance with the Inspection Clause, 52.246-2 of Section E. Plants failing to meet the specifications shall be rejected. If twenty-five (25%) percent or more of the plants of any variety fail to meet the specifications the entire shipment of that variety may be rejected.

DELIVERY REQUIREMENTS

Plants shall be delivered to designated locations within the National Capital Region no later than twenty four hours after a telephone notification by the Contracting Officer or his representative, of the quantities and varieties required.

SECTION 02926

[SOIL MODIFICATION] [TOPSOIL] AND SEEDING

PART 1 GENERAL

1.01 WORK INCLUDED

A. Preparation of subgrade.

B. Preparation of seed bed.

C. Seeding

D. Seed protection.

E. Maintenance

1.02 RELATED WORK

A. Section 02200: Earthwork; Stripping Existing Topsoil

C. Section 02950: Trees, Shrubs, and Groundcover

1.03 REFERENCE STANDARDS

A. Topsoil: National Soil and Fertilizer Research Committee

B. Seed:

1. Association of Official Seed Analysts

2. Extension Services of University of Maryland or Virginia Polytechnic Institute and State University.

C. Fertilizer:

1. Association of American Plant Food Control Officials

2. FS 0-F-241 - Fertilizers, Mixed, Commercial.

D. Lime:

1. Association of Official Agricultural Chemists.

2. Association of American Plant Food Control Officials.

1.04 SUBMITTALS

A. Samples:

1. Mulching material: 1/2 cubic foot.

2. Establishment blanket: 1 square yard.

3. The right is reserved to inspect and sample all topsoil at the source and at the time of delivery. These inspections shall be made without cost to the Contractor.

B. Material Certification and Test Results:

1. Topsoil:

a. Location of all sources.

b. Certified report of chemical analysis from State Agricultural Experiment Station or approved agricultural laboratory performed not more than 60 days prior to date of submission, including acidity, salinity, fertility, texture and recommended rate of application of lime and fertilizer to [imported and] existing topsoil to sustain turf growth.

2. Seed: Submit seed vendors certification of grass seed mixture, indicating percentages of weight, purity and germination for each grass species.

3. Fertilizer and Lime: Certification of chemical composition.

1.05 DELIVERY, STORAGE AND HANDLING

A. Compost: Deliver in dry, unfrozen, completely composted condition.

B. Topsoil: Deliver in dry, unfrozen, condition.

C. Seed: Deliver in original containers showing analysis of seed mixture, percentage of pure seed, year of production, net weight, date of packaging and location of packaging. Damaged packages are not acceptable. Store in a manner to prevent wetting and deterioration.

D. Fertilizer: Deliver in unopened waterproof bags showing weight, chemical analysis and name of manufacturer. Store in a manner to prevent wetting and deterioration.

F. Lime: Deliver in unopened waterproof bags showing weight, composition, texture, and name of manufacturer. Bulk lime may be approved by the Contracting Officer provided the same information is included on the bill of lading. Store in a manner to prevent wetting and deterioration.

PART 2 PRODUCTS

2.01 COMPOST:

A. Screened Compost: "Com-PRO Agricultural Compost" as available through Maryland Environmental Services, 2020 Industrial Drive, Annapolis, MD 21401 (301/261-8596); completely composted and free from all extraneous materials such as glass, paper, plastics, etc.

2.02 IMPORTED TOPSOIL

A. Topsoil shall be the natural, original surface soil, shall be in a friable condition and shall contain less than 3 percent subsoil, hardpan material, stones and clods larger than 1/2 inch in diameter. It shall also be free of sticks, tree or shrub roots, debris, and other material undesirable for plant growth. The area and the topsoil shall be free of undesirable plants such as, but not limited to, bermudagrass, nut sedge, mugwort or noxious weeds as set forth in the Federal Seed Act.

B. The topsoil shall contain at least 1.75 percent organic matter. It shall be a sandy loam consisting of at least 5 but not more than 20 percent clay, at least 10 but not more than 40 percent silt, and not less than 45 nor more than 80 percent sand. It shall have a pH between 6.0 - 7.0. Soluble salts (salinity) shall not exceed 500 ppm. Soil Fertility shall be "High" in natural nutrients based on the coordinated ratings in pounds per acre as established by the National Soil and Fertilizer Research Committee.

C. Topsoil which has been manufactured by blending materials which individually do not meet the requirements of this specification will not be accepted even though the resulting blend meets the organic matter, mechanical analysis, pH and soluble salts requirements. Agricultural limestone at not more than 5 pounds per cubic yard of topsoil may be used to adjust the pH provided it is well mixed in a manner which does not destroy the structure of the soil.

OR

2.03 EXISTING TOPSOIL

A. Natural, fertile agricultural soil, free from subsoil, slag, clay, stones, lumps, plants, roots, sticks, crabgrass, noxious weeds, and foreign matter if approved for use by Contracting Officer.

B. [Do not] shred and mix existing turf into existing topsoil. [Strip existing turf and remove from job site.]

2.04 FERTILIZER

A. Standard commercial starter fertilizer of 10-10-10 grade, FS 0-F-241, containing 10% nitrogen, 10% phosphoric acid, and 10% potash; uniform in composition, dry and free flowing material suitable for application by a common fertilizer distributor or other approved equipment.

2.05 LIME

A. Finely ground agricultural limestone, 90% calcium carbonate equivalent, conforming to standards of Association of Official Agricultural Chemists and meeting the following sieve analysis:

1. At least 98% passing a 20 mesh sieve and 75% passing a 100 mesh sieve.

2.06 SEED

A. Conform to applicable State and Federal regulations and to test provisions of Association of Official Seed Analysts, as follows:

Permanent Seed Type	Proportion by Weight	Minimum Purity	Minimum Germination
1. Seed Mixtures for Lawn Areas			
Use following if area to be seeded will receive intense use and low maintenance.			
a. Mixture A:			
Certified Tall Fescue: One or more varieties listed as "Proven Cultivars" in the most recent turf recommendations published by the Extension Services of the University of Maryland or Virginia Polytechnic Institute and State University with not less than 30% of one variety.	90-100%	98%	85%
Certified Kentucky Bluegrass: South Dakota or Kenblue.	0-10%	98%	85%
Use following mixture if area to be seeded will receive high level of maintenance and high visibility.			
b. Mixture B:			
Kentucky Bluegrass: At least three varieties listed in "Category I - Proven Cultivars" in the most recent turf recommendations published by the Extension Services of the University of Maryland or Virginia Polytechnic Institute and State University with not more than 35% nor less than 10% of the mixture being	80-100%	98%	85%

any one variety.

Red Fescue: Pennlawn	0-20%	98%	85%

Use following mixture if quick, sturdy cover is needed.

c. Mixture C:

Pennfine Perennial Ryegrass	1/3	98%	85%
Regal Perennial Ryegrass	1/3	98%	85%
Citation Perennial Ryegrass	1/3	98%	85%

OR

2. Seed Mixture for Meadow areas:

Permanent Seed Type	Proportion By Weight
Red Clover	40%
Timothy	30%
Alsike Clover	30%

2.07 ACCESSORIES

A. Mulching Material: Oat or wheat straw or wood cellulose fiber, reasonably free from weeds, growth, germination-inhibiting ingredients or foreign matter detrimental to plant life, and in dry condition. Hay or chopped cornstalks are not acceptable.

B. Establishment Blanket: Uniform, open weave jute or excelsior matting.

PART 3 EXECUTION

3.01 GENERAL

A. Perform seeding work after planting and other work affecting ground surface has been completed.

B. Seed lawn areas between March 1st and April 15th or between August 1st and October 31st.

C. Seed meadow areas in August-September or February-April.

D. Do not seed during drought, high winds, when ground is frozen, when temperatures are 32 degrees Fahrenheit or lower, excessive moisture or other conditions which are likely to damage the seed.

3.02 PREPARATION OF SUB-GRADE

A. Remove contaminated subsoil.

B. Thoroughly till areas to be seeded to a 6" minimum depth.

C. Remove stones, and debris, greater than 1" diameter and dispose of off site.

3.03 PREPARATION OF SEED BED

A. Perform work during dry weather and on dry, unfrozen subgrade.

Delete the following if only meadow areas are in project.

B. After lawn areas to be seeded have been tilled, spread stockpiled topsoil and supplement with [compost] [imported topsoil] to a minimum total depth of 3".

Do not use lime if compost is used.

C. Apply lime evenly at [rate of 50 # per 1000 sq. ft.] [rate determined by soil testing] and lightly rake into top 3" of soil.

Include the following item if compost is used.

D. Cultivate to a depth of 6-9" so that compost is incorporated and soil is thoroughly pulverized.

E. Grade finish surface of seed bed to smoothness comparable to results obtained by hand raking, leaving it clean and free of stones, debris, and depressions.

F. Blend final grades with existing adjacent ones. Leave entire area drainable and free from abrupt changes in slope.

G. After preparation of finished surface, apply fertilizer evenly at [rate of 10# per 1000 square ft.] [rate determined by soil testing] and lightly rake into top 1" of soil.

3.04 SEEDING

A. Seed areas disturbed by construction, where shown on drawings, or as directed.

1. Seeding Rate:

a) Mixture A: 6 lbs./1000 sq. ft.
b) Mixture B: 2 lbs./1000 sq. ft.
c) Mixture C: 5 lbs./1000 sq. ft.
d) Meadow Areas: 0.5 lbs/1000 sq. ft.

B. Use either dry or wet application as approved.

1. Dry Application:

a) Apply seed mixture immediately after final soil preparation.

b) Compact the seed bed by means of a cultipacker or other similar equipment.

c) As shown on the plans, apply mulch at 1½ - 2 tons per acre or to cover 50-60 percent of the soil surface over the seed and anchor using a mulch tiller, asphalt emulsion, chemical mulch binder, twine or netting, as approved. If asphalt materials are to be used, take precautionary measures to prevent marking or defacing structures, pavements, utilities or plantings.

d) Apply water with fine spray to wet the soil 1 inch deep immediately after each area has been sown.

OR

2. Wet Application: (Hydroseeding)

a) Seed in the form of an aqueous mixture. Fertilizer may be applied during hydroseeding if the rate used during soil preparation is reduced in half.

b) Constantly agitate all mixtures.

c) Ensure uniform coverage and protect against misses and overlaps.

d) Apply at a minimum rate of 1000 gal./acre.

e) Spread straw as a protective covering either by hand or with a straw blower. Use same procedure as followed in dry application.

f) A cellulose fiber or approved equal may be used in the aqueous mixture at the rate of 1500 lbs./acre instead of applying straw.

3.05 SEED PROTECTION ON SLOPES

A. Cover seeded slopes where grade is 3:1 or greater with establishment blanket. Roll matting down over slopes without stretching or pulling.

B. Lay matting smoothly on soil surface, burying top end of each section in narrow 6" deep trench. Leave 12" overlap from top roll over bottom roll. Leave 4" overlap over adjacent section.

C. Staple outside edges and overlaps at 36" intervals.

D. Lightly dress slopes with topsoil to ensure close contact between matting and soil.

E. In ditches, unroll matting in direction of flow. Overlap ends of strips 6" with upstream section on top.

3.06 PROTECTION

A. Install post and rope barriers around seeded areas. Tie cloth or ribbon to rope at 10' intervals.

B. Install "KEEP OFF" signs at appropriate locations.

3.07 MAINTENANCE

A. Maintain surfaces and supply additional topsoil where necessary, including areas affected by erosion.

B. Water to ensure uniform seed germination and to keep surface of soil damp.

C. Apply water slowly so that surface of soil will not puddle and crust.

D. Cut lawn areas when grass reaches height of 3". Maintain minimum height of 2". Do not cut more than 1/3 of blade at any one mowing. Do not mow meadow areas.

E. After first mowing of lawn, water grass sufficiently to moisten soil from 3" to 5" deep.

F. Reseed damaged grass areas showing root growth failure, deterioration, bare or thin spots, and erosion.

3.08 ACCEPTANCE

A. Seeded areas will be accepted when an even and uniform stand of turf, 3" tall in lawn areas, 5" tall in meadow areas, is properly established.

PART 4 MEASUREMENT AND PAYMENT

Use the following if the extent of work of this section is well defined and relatively minor.

4.01 [SOIL MODIFICATION] [TOPSOIL] AND SEEDING

A. Payment will be made at the contract lump sum price.

OR

B. Measurement will be the number square yards, to the nearest square yard, based on field measurements of the actual area seeded. Payment will be made at the Contract Unit price per Square yard. [for lawn areas or for meadow areas.]

Use the following if the work of this section involves questionable quantities or has a large monetary value which is a significant portion of the total project.

4.02 COMPOST

A. Measurement will be the number of cubic yards, to the nearest cubic yard, as determined by delivery tickets and verified by field measurements of the trucks. Payment will be made at the contract unit price per cubic yard.

4.03 IMPORTED TOPSOIL

A. Measurement will be the number of cubic yards, to the nearest cubic yard, verified by delivery tickets and field measurement of trucks. Payment will be made at the contract unit price per cubic yard.

4.04 SEED

A. Measurement will be the number of pounds, to the nearest 10 pounds, verified by manufacturer's packaging labels. Payment will be made at the contract unit price per pound [for each seed mixture].

4.05 FERTILIZER

A. Measurement will be the number of pounds, to the nearest 10 pounds, verified by manufacturer's packaging labels. Payment will be made at the contract unit price per pound.

4.06 LIME

A. Measurement will be the number of pounds, to the nearest 50 pounds, verified by manufacturer's packaging labels. Payment will be made at the contract unit price per pound. Except that where bulk application has been approved, measurement shall be by the ton, to the nearest tenth of a ton, verified by delivery tickets.

4.07 ACCESSORIES, PROTECTION, MAINTENANCE

A. Payment will be included under the unit price for seed.

SECTION 02928

[SOIL MODIFICATION] [TOPSOIL] AND SODDING

PART 1 GENERAL

1.01 WORK INCLUDED

A. Preparation of sub-grade.

B. Preparation of sod bed.

C. Laying sod.

D. Maintenance.

1.02 RELATED WORK

A. Section 02200: Earthwork; stripping existing topsoil.

B. Section 02950: Trees, Shrubs and Groundcover

1.03 REFERENCE STANDARDS

A. Topsoil: National Soil and Fertilizer Research Committee.

B. Sodding: American Sod Producers Association Guideline Specifications for Sodding.

C. Fertilizer:

1. Association of American Plant Food Control Officials.

2. FS 0-F-241 - Fertilizers, Mixed, Commercial.

D. Lime:

1. Association of Official Agricultural Chemists.

2. Association of American Plant Food Control Officials.

1.04 SUBMITTALS

A. Material Certifications and Test Results:

1. Topsoil:

a. Location of all sources
b. Certified report of chemical analysis from State Agricultural Experiment Station or approved agricultural laboratory performed not more than 60 days prior to date of submission, including acidity, salinity, fertility, texture, and recommended rate of application of lime and fertilizer to [imported and] existing topsoil to sustain turf growth.

c. The right is reserved to inspect and sample all topsoil at the source and at the time of delivery. These inspections shall be made without cost to the Contractor.

2. "Certified Sod": Official certification label and dated invoice, bill of lading or labeling information document.

3. Fertilizer [and lime]: Certification of chemical composition.

1.05 DELIVERY, STORAGE AND HANDLING

A. Screened Compost: Deliver in dry, unfrozen, completely composted condition.

B. Topsoil: Deliver in dry, unfrozen condition.

C. Sod: Harvest and deliver within period of 24 hours and keep moist until placement.

D. Fertilizer: Deliver in unopened waterproof bags showing weight, chemical analysis, and name of manufacturer. Store in a manner to prevent wetting and deterioration.

E. Lime: Deliver in unopened waterproof bags showing weight, composition, texture, and name of manufacturer. Bulk lime may be approved by the Contracting Officer provided the same information is included on the bill of lading. Store in a manner to prevent wetting and deterioration.

PART 2 PRODUCTS

2.01 COMPOST:

A. Screened Compost: "Com-PRO Agricultural Compost" as available through Maryland Environmental Services, 2020 Industrial Drive, Annapolis, MD 21401 (301/261-8596); completely composted and free from all extraneous materials such as glass, paper, plastics, etc.

2.02 IMPORTED TOPSOIL

A. Topsoil shall be the natural, original surface soil, shall be in a friable >condition and shall contain less than 3 percent subsoil, hardpan material, stones and clods larger than 1/2 inch in diameter. It shall also be free of sticks, tree or shrub roots, debris, and other material undesirable for plant growth. The area and the topsoil shall be free of undesirable plants such as, but not limited to, bermudagrass, nut sedge, mugwort or noxious weeds as set forth in the Federal Seed Act.

B. The topsoil shall contain at least 1.75 percent organic matter. It shall be a sandy loam consisting of at least 5 but not more than 20 percent clay, at least 10 but not more than 40 percent silt, and not less than 45 nor more than 80 percent sand. It shall have a pH between 6.0 - 7.0. Soluble salts (salinity) shall not exceed 500 ppm. Soil Fertility shall be "High" in natural nutrients based on the coordinated ratings in pounds per acre as established by the National Soil and Fertilizer Research Committee.

C. Topsoil which has been manufactured by blending materials which individually do not meet the requirements of this specification will not be accepted even though the resulting blend

meets the organic matter, mechanical analysis, pH and soluble salts requirements. Agricultural limestone at not more than 5 pounds per cubic yard of topsoil may be used to adjust the pH provided it is well mixed in a manner which does not destroy the structure of the soil.

2.03 EXISTING TOPSOIL

A. Natural, fertile agricultural soil, free from subsoil, slag, clay, stones, lumps, plants, roots, sticks, crabgrass, noxious weeds, and foreign matter if approved for use by Contracting Officer.

B. [Do not] shred and mix existing turf into existing topsoil. [Strip existing turf and remove from job site.]

2.02 SOD

A. General:

1. Machine cut at uniform soil thickness of 3/4", +/- 1/4", excluding top growth and thatch. Cut individual pieces at least 12" wide and of length such that each piece is at least | sq. yd. Maximum allowable deviation from standard width is 5%.

2. Broken pieces and torn or uneven ends will not be accepted. Each piece of sod must be strong enough to support its own weight and retain its size and shape when suspended vertically from a firm grasp on the upper 10% of the piece.

3. Each load of "Certified Sod" or Certified Turf" shall be accompanied by, in the same vehicle, an official certification label and that label must be attached to a dated invoice, bill of lading or labeling information document.

Use one of the following if area to be sodded will receive high visibility and high level of maintenance.

B. Certified Kentucky Bluegrass Sod

1. Certified Kentucky bluegrass sod: Kentucky bluegrass sod shall be living "Certified Sod" or "Certified Turf."

2. It shall be grown from a blend Kentucky bluegrass seed which meets the requirements for certification. Certification shall be by the State Certifying Agency such as the Maryland Department of Agriculture, the Virginia Crop Improvement Association or the appropriate agency of another state.

OR

2. It shall be grown from a blend, which meets the requirements for certification, of not less than 30% of one of the following: Columbia, Enmundi, Escort, Monopoly, Victa or Wabash, and at least two other varieties recommended by the Maryland-Virginia Turfgrass Cultivar Recommendations Work Group. No more than 35% or less than 10% of the mixture may be any one variety. Certification shall be by the State Certifying Agency such as the Maryland Department of Agriculture, the Virginia Crop Improvement Association or the appropriate agency of another state.

Use following if area to be sodded will receive intense use and low maintenance.

C. Certified Tall Fescue Sod

1. Living "Certified Sod" or Certified Turf" grown from a mixture of one or more varieties of tall fescue seed, and Kentucky bluegrass seed, which meets the certification requirements published by the extension services of the University of Maryland or Virginia Polytechnic Institute and State University.

If more than one type of sod is used on a job, sod schedule may be needed to specify where each type of sod is to be used.

2.03 FERTILIZER

A. Standard commercial mix of 10-10-10-grade, FS O-F-241, containing 10% nitrogen, 10% phosphoric acid and 10% potash; uniform in composition, dry and free flowing material suitable for application by a common fertilizer distributor or other approved equipment.

2.04 LIME

A. Finely ground agricultural dolomitic limestone, 90% calcium carbonate equivalent, conforming to standards of Association of Official Agricultural Chemists and meeting the following sieve analysis:

1. At least 98% passing a 20-mesh sieve and 75% passing a 100-mesh sieve.

PART 3 EXECUTION

3.01 PREPARATION OF SUB-GRADE

A. Protect existing underground improvements from damage.

B. Remove contaminated subsoil.

C. Thoroughly till areas to be sodded to a 6" minimum depth.

D. Remove foreign materials, plants, roots, stones and debris greater than 1" diameter and dispose of off-site. Do not bury foreign materials.

3.02 PREPARATION OF SOD BED

A. Perform work during dry weather and on dry, unfrozen subgrade.

B. After areas to be sodded have been tilled, spread stockpiled topsoil and supplement with [compost] [leaf mold] [imported topsoil] to a minimum total depth of 3".

Do not use lime if compost is used.

C. Apply lime evenly at [rate of 50# per 1,000 sq. ft.] [rate determined by soil testing] and work into the top 3" of soil.

Use following if compost/leaf mold is used.

D. Cultivate to a depth of 6-9" so that [compost] [leaf mold] is incorporated and soil is thoroughly pulverized.

E. Grade finish surface of sod bed to smoothness comparable to results obtained by hand raking, leaving it clean and free of stones, debris and depressions.

F. Blend final grades with existing adjacent ones. Leave entire area drainable and free from abrupt changes in slope.

G. After preparation of finished surface, apply fertilizer evenly at [rate of 10# per 1,000 sq. ft.] [rate determined by soil testing] and lightly rake into top 1" of soil.

3.03 LAYING SOD

A. Do not lay sod until prepared sod bed has been approved by Contracting Officer.

B. Lay sod within 12 hours after delivery to prevent deterioration.

C. Do not lay sod during freezing weather, when the sod or ground is frozen, or when the sodding areas are too wet or too dry.

D. Place sod by hand with close joints and not overlapping. Plug all gaps between sections of sod and openings at angles with [compost-soil mixture] [topsoil] and pieces of sod cut to fit.

E. Install sod smooth and flush with adjoining paving and transition smoothly to existing grass areas.

F. Thoroughly water sod immediately after installation to a depth of 4".

G. After sod and soil have dried sufficiently to prevent damage, roll sodded areas to ensure good bondage between sod and soil and remove minor depressions and irregularities.

H. If sod workmanship is not satisfactory, take sod up and relay as directed by the Contracting Officer.

3.04 MAINTENANCE

A. Roll, water, mow and otherwise maintain all sodded areas a minimum of 30 days and until final acceptance of contract. Do not allow sod to dry out.

B. If requested by Contracting Officer, install post and rope barriers around sodded areas. Tie cloth or ribbon to rope at 10' intervals.

PART 4 MEASUREMENT AND PAYMENT

Use the following if the extent of work of this section is well defined and relatively minor.

4.01 [SOIL MODIFICATION][TOPSOIL] AND SODDING

A. Payment will be made at the contract lump sum price.

OR

B. Measurement will be the number of square yards, to the nearest square yard, based on field measurement of the actual areas sodded. Payment will be made at the contract unit price per square yard [for each type of sod].

Use the following if the work of this section involves questionable quantities or has a large monetary value which is a significant portion of the total project.

4.02 COMPOST

A. Measurement will be the number of cubic yards, to the nearest cubic yard, [verified by weight tickets] [as determined by field measurements]. Payment will be made at the contract unit price per cubic yard.

4.03 IMPORTED TOPSOIL

A. Measurement will be the number of cubic yards, to the nearest cubic yard, as determined by field measurement of the trucks and verified by delivery tickets. Payment will be made at the contract unit price per cubic yard.

4.04 SOD

A. Measurement will be the number of square yards, to the nearest square yard, based on measurements of the actual area sodded. Payment will be made at the contract unit price per square yard [for each type of sod] .

4.05 FERTILIZER

A. Measurement will be the number of pounds, to the nearest 10 pounds, verified by manufacturer's packaging labels. Payment will be made at the contract unit price per pound.

4.06 LIME

A. Measurement will be the number of pounds, to the nearest 50 pounds, verified by manufacturer's packaging labels. Payment will be made at the contract unit price per pound.

4.07 ACCESSORIES, PROTECTION, MAINTENANCE

A. Payment will be included under the unit price for sod.

SECTION 02950

TREE, SHRUB AND/OR GROUND COVER PLANTING SPECIFICATIONS

PART 1 GENERAL

1.01 WORK INCLUDED

Furnishing, delivering and planting all plant materials in the locations and in the arrangement shown on the plans or as directed by the Contracting Officer, including the digging and preparation of the individual planting pits, placing the necessary prepared topsoil and mulch, etc., watering, wrapping, staking, guying, pruning, maintenance and other incidentals necessary to complete the planting and 1-year guarantee.

1.02 RELATED WORK

1.03 QUALITY ASSURANCE

A. Plant Materials

1. Plants must meet all requirements and recommendations of the American Standard for Nursery Stock, sponsored by the American Association of Nurserymen, Inc, 1250 I Street, N.W. Suite #500, Washington, D.C. 20005, in effect on date of Invitation for Bid.

2. Regulations Governing Entry of Plants and Plant Products into District of Columbia: Shipments or orders of plant material must be properly inspected at nursery and/or growing site by authorized Federal and State authorities or inspectors as required by Bureau of Entomology and Plant Quarantine, U.S. Department of Agriculture, Washington, D.C. for necessary transportation of same, before removal from State or District in which nursery and/or growing site is located; each shipment, invoice or order of stock must be declared and certified free from disease of any kind. All necessary inspection certificates must be filed with Contracting Officer prior to acceptance and payment.

3. The right is reserved to inspect and select all plant materials before plants are dug. This inspection, if made, shall be at the nursery or growing site by the Project Landscape Architect or Horticulturist without cost to the Contractor.

4. Contractor's work must conform to good horticultural practices recognized by the trade.

5. Final acceptance of all plant materials will be given only after materials have been planted, and inspected by project Landscape Architect or Horticulturist.

B. Topsoil

1. Contractor must notify Contracting Officer of location of all sources of the topsoil and furnish to Contracting Officer a certified report from the agricultural experiment station or approved agricultural laboratory of an analysis performed not more than 60 days prior to the date of submission attesting that proposed topsoil material meets all requirements specified for acidity, salinity, fertility, texture and organic matter.

2. The right is reserved to inspect and sample all topsoil at the source and at the time of delivery. These inspections shall be made without cost to the Contractor.

1.04 REFERENCE STANDARDS

A. Plant Materials: American Standard for Nursery Stock, published by the American Association of Nurserymen, 1250 I Street, N.W. Suite #500, Washington, D.C. 20005 in effect at date of planting.

B. Plant Names: Plant names must agree with nomenclature of "Hortus Third" by the Staff of the L.H. Bailey Hortarium, Cornell University.

C. Fertilizer

1. Association of American Plant Food Control Officials

2. FS 0-F-241 - Fertilizers, Mixed, Commercial

1.05 DELIVERY, STORAGE, AND HANDLING

A. Plant Materials

1. Contractor must notify Contracting Officer, in advance, when plant material is to be delivered to site and manner of shipment and must furnish an itemized list of actual quantity and sizes.

2. All plant materials must be protected from weather and adequately packed to provide protection against climate and breakage during transit. When shipment is made by open vehicle, plant materials must be tied and covered to minimize windwhipping and drying. Evergreen plants and deciduous plants in leaf must be sprayed with antitranspirant in accordance with the manufacturer's instructions to afford protection from drying. When shipment is made by closed vehicle, plants must be carefully packed and adequately ventilated to prevent "sweating" of plants during transit.

3. Care must be exercised at all times during the handling operations to prevent damage to bark, branches, and root system and to preclude cracked plant balls. Plant no balled plant if ball is cracked or broken either before or during planting operation. All balls over 36" diameter must be platformed.

4. Plants must be protected upon arrival at site by being thoroughly watered and properly maintained until planted, by covering with wet soil, peat moss, suitable straw mulch material, or other approved methods (including use of an approved antitranspirant), unless planted within 24 hours of delivery.

5. Labels shall be durable and legible stating the correct plant name and size in weather-resistant ink or embossed letters. Labels shall be securely attached to all plants, bundles or containers of plant material. Those attached directly to plants shall be attached in a manner which will not restrict growth. At least one plant of each genus, species and variety or cultivar shall be labeled.

6. Plants cannot be planted on job until inspected at receiving site and approved by Project Landscape Architect or Horticulturist. Plants not meeting specifications for

quality herein stated, or plants that show improper handling or arrive onsite in unsatisfactory condition will be rejected. All rejected plants must immediately be removed and disposed of by Contractor and must be replaced with approved nursery stock of designated variety, size, age, etc., without additional compensation.

B. Topsoil

1. Must be approved by Contracting Officer before delivered to site. Any material not meeting requirements of this specification will be rejected on or after delivery.

2. Topsoil must not be delivered or handled in a frozen or a muddy condition.

C. Compost

1. Deliver in dry, unfrozen, completely composted condition.

D. Leaf Mold

1. Deliver in dry, unfrozen, completely composted condition.

E. Fertilizer

1. Deliver in unopened sealed standard containers showing weight, chemical analysis, and name of manufacturer.

1.06 GUARANTEE

A. Plant Material will be guaranteed for a 1-year period beginning at the date of acceptance of the contract. The contractor will, however, be required to replace an individual plant only once.

1.07 SAMPLES

A. Submitted for each type of material proposed for use as the Contracting Officer may require.

B. Each sample must be typically representative of kind and quality of material provided for use. Contracting Officer has right to reject any or all samples which fail to meet requirements of these specifications and to require that additional samples be submitted until an acceptable sample has been approved.

C. Deliver no materials relative to required samples to site of work until those samples have been accepted and approved in writing.

D. Contracting Officer will retain submitted samples for use in comparison with all materials delivered by the Contractor.

PART 2 PRODUCTS

2.01 PLANT MATERIALS

A. Plant material shall be supplied by prospective bidders from plant hardiness Zone 7 as developed by U.S.D.A., A.R.S. based on expected low temperatures. If the specified cultivar

or variety is not available from Zone 7, material from Zone 6 may be accepted at the discretion of the Contracting Officer.

B. Nursery Grown Stock normally developed and typically representative of species and/or variety stated. Uniformly and fully branched as seen from all sides, strong and healthy and with a well-formed, vigorous and unbroken root system; all single-trunk trees must have straight trunks, be free of disease, insect damage to bark or branches, or any other defect, unhealthy condition or malformation.

2.02 IMPORTED TOPSOIL

A. Topsoil shall be the natural, original surface soil, shall be in a friable condition and shall contain less than 3 percent subsoil, hardpan material, stones and clods larger than 1/2 inch in diameter. It shall also be free of sticks, tree or shrub roots, debris, and other material undesirable for plant growth. The area and the topsoil shall be free of undesirable plants such as, but not limited to, bermudagrass, nut sedge, mugwort or noxious weeds as set forth in the Federal Seed Act.

B. The topsoil shall contain at least 1.75 percent organic matter. It shall be a sandy loam consisting of at least 5 but not more than 20 percent clay, at least 10 but not more than 40 percent silt, and not less than 45 nor more than 80 percent sand. It shall have a pH between 6.0 - 7.0. Soluble salts (salinity) shall not exceed 500 ppm. Soil Fertility shall be "High" in natural nutrients based on the coordinated ratings in pounds per acre as established by the National Soil and Fertilizer Research Committee.

C. Topsoil which has been manufactured by blending materials which individually do not meet the requirements of this specification will not be accepted even though the resulting blend meets the organic matter, mechanical analysis, pH and soluble salts requirements. Agricultural limestone at not more than 5 pounds per cubic yard of topsoil may be used to adjust the pH provided it is well mixed in a manner which does not destroy the structure of the soil.

2.03 EXISTING TOPSOIL

A. Utilize as approved by the Contracting Officer

B. Do not shred and mix existing turf into existing topsoil. Strip existing turf and remove from job site.

2.04 SCREENED COMPOST

A. "Com-pro" agricultural compost as available through Maryland Environmental Services, 2020 Industrial Drive, Annapolis, MD 21401 (301/261-8596), or approved equal, completely composted and free from all materials such as glass, paper, plastics, etc.

2.05 SCREENED LEAF MOLD

A. As available through Maryland Environmental Services, 2020 Industrial Drive, Annapolis, MD 21401 (301/261-8596), or approved equal, completely composted and free from all materials such as glass, paper, plastics, etc.

2.06 PEAT MOSS

A. Peat moss shall be raw Michigan peat or approved equal, obtained from fresh water sites of sedge peat and/or reed peat deposits in which the organic matter consists of decomposed plant residues containing a negligible amount of wood matter and shredded to resemble the texture of cultivated peat.

B. Peat moss shall not have been cultivated or aged and shall meet the following requirements:
(l) Minimum of 85 percent pure organic matter.
(2) Maximum of 650 percent moisture by dry weight as received.
(3) Minimum of l00 percent water absorption per 24 hours submersion in water by weight.
(4) Minimum of 350 percent water absorption, from a dry basis by weight.
(5) Maximum weight as received, 30 lbs. per cubic foot, equivalent to 2.45 cubic yards per ton. All materials shall pass as l-inch sieve and not less than 50 percent shall be retained on a 1/2-inch sieve.

2.07 SAND

A. Sharp, clean and well-graded with 100 percent passing the 3/8" sieve.

2.08 PREPARED SOIL MIXTURE (To be used only in beds of four or more plants or where adequate drainage exists or is provided)

A. 5 parts topsoil, 1 part [compost] or [leaf mold] and 1 part sand. Thoroughly mixed by volume at designated locations in the presence of the Contracting Officer or his representative.

2.09 FERTILIZER

A. Trees and Shrubs:

1. Slow release type contained in polyethylene perforated bags with micropore holes for feeding such as Eeesy Grow as manufactured by ADCO Works, P.O. Box 310, Hollis, N.Y. 11423 or approved equal.

2. For tree planting, the bags shall contain 4 ounces of soluble 16-8-16 fertilizer per unit designed to last for 8 years. For shrub, planting the bags shall contain 1 ounce of soluble 16-8-16 fertilizer per unit, designed to last for 3 years.

B. Groundcover:

1. Standard commercial mix of 5-10-15 grade, FS 0-F-241, containing 5% nitrogen, 10% phosphoric acid and 15% potash; uniform in composition, dry and free-flowing material.

2.10 MULCH

A. Trees and Shrubs: Shredded hardwood (medium grade) approved in advance by Contracting Officer, free of sticks, stones, clay or any other matter injurious to plant growth.

B. Groundcover: Shredded hardwood (fine grade) approved in advance by Contracting Officer, free of sticks, stones, clay or any other matter injurious to plant growth.

2.11 ANTITRANSPIRANT

A. Wilt-Pruf, as manufactured by Nursery Specialty Products, Inc., 203 East 475th4 Street, New York, New York 10017, or approved equal.

2.12 ACCESSORIES

A. Support Stakes: rough cypress, hard pine, cedar, oak or locust, free from unsound or loose knots and rot and from injurious cross grain and sap wood, or any other defect; 2" x 2" by 4 feet or 2" x 2" by 8 feet, pointed on one end, length as specified for tree size. Painted or stained dark brown color approved in advance by Contracting Officer.

B. Wrapping Materials: first quality, 4-inch wide, bituminous-impregnated two-ply paper, specifically manufactured for tree wrapping; insect infestation resistant.

C. Twine: lightly tarred jute, not less than 2-ply.

D. Guys: 12-gauge annealed zinc-coated wire, enclosed in a rubber garden hose (minimum diameter of 1/2 inch; 3/4 inch for larger trees) where it comes in contact with tree trunk or branches. Hose color: black or dark green, as approved by Contracting Officer; all one color.

PART 3 EXECUTION

3.01 PREPARATION

A. Stake tree locations as shown on plans or as designated by Contracting Officer.

B. Remove existing trees or shrubs to be replaced in their entirety, including stump and roots, and dispose of off site.

C. All tree pits shall be excavated a minimum of 18 inches or 6 inches deeper than the root ball, whichever is greater, and 24 inches wider than the root ball, except that a pillar of undisturbed soil 1/3 the diameter of the ball shall be left to support the ball 3-4 inches above the level at which the plant was grown in the nursery. The remainder of the bottom of the pit shall be loosened an additional 6 inches and rocks and debris removed from that 6 inches and disposed of off site. All tree pits shall be dug circular in outline with the sides vertical and the bottom flat, except as noted. Side walls shall be roughened and not glazed.

D. All shrub beds shall be excavated to a depth of l8 inches. All ground cover (ivy, etc.) beds shall be excavated to a depth of 12 inches. After the soil has been removed, the bottom of the beds shall be rototilled to remove any hardpan that may exist and rocks and debris shall be removed and disposed of off site.

E. Excavate all beds and tree planting holes so that contour of bottom is parallel to that of final surface grade.

F. Dispose of excavated soil not approved for reuse off site.

G. Backfill all excavated areas with prepared soil mixture in accordance with instructions under Tree, Shrub or Groundcover Installation.

H. Establish finished grade of soil as shown on plan or as directed by Contracting Officer.

I. No beds or holes will be allowed to remain open longer than one day; barricade or rope off beds or holes left open overnight in a manner approved by the Contracting Officer for the protection of the public.

3.02 INSTALLATION

A. Conduct planting operations under favorable weather conditions throughout the period of this contract as determined by the Contracting Officer. Install no planting during adverse weather or during periods when soil conditions are unfavorable as determined by the Contracting Officer.

B. Do not place topsoil when ground is frozen, excessively wet, or in a condition that the soil cannot be worked easily and dressed smoothly.

C. Place plant materials for review and final orientation by Project Landscape Architect or Horticulturist prior to installation. Make any changes in location or proposed planting as required, without additional cost to government.

D. Tree Planting

1. After pits have been dug at the designated locations, and they have been approved by the Contracting Officer's representative, the pit shall be backfilled with loosened soil to the top of the pillar. Upright plants shall be kept in a vertical position. All plants shall be handled only by the earth ball. Handling by the plant stem or foliage will be cause for rejection of that plant. All earth balls shall be firm and undamaged. Cracked or crushed balls shall be rejected.

2. Backfill with planting mixture, tamping at 12" intervals to fill voids around ball.

3. When pit is half full, place fertilizer in accordance with manufacturer's recommendations, or with the following specifications, before the balance of the pit is backfilled.

< 1½" caliper - 2 (4 oz.) packets, 6-8" deep.
1½ - 2" caliper - 3 (4 oz.) packets, 6-8" deep.
2½ - 3" caliper - 4 (4 oz.) packets, 6-8" deep.
3½ - 4" caliper - 5 (4 oz.) packets, 6-8" deep.
4½ - 5" caliper - 6 (4 oz.) packets, 6-8" deep.

4. After filling three-quarters up the earth ball, loosen burlap and lay back off the top of the ball. Remove nylon cording. Backfill balance of pit, firm around ball, and thoroughly water.

E. Shrub Planting

1. After removal of soil from shrub beds and preparation of base, backfill with prepared soil mixture to depth sufficient to bring top of plant ball set on it 1/8 of its depth above the proposed grade. Tamp well. Beds shall be crowned or sloped to insure surface drainage.

2. Space plants as specified. Handle plants only by earth ball. Plants handled by tops will be rejected. All earth balls must be firm and undamaged; cracked or crushed balls will be rejected.

3. Container Stock: Remove plants from containers with root balls intact. Score root balls on four sides with sharp knife or other sharp instrument and flare out the four quadrants on the lower third of the ball to prevent a girdled root system.

4. Place fertilizer in accordance with the manufacturer's recommendations or with the following specifications, before the balance of the bed is backfilled:

   12-24" - 1 (1 oz.) packet next to roots.
   24-36" - 2 (1 oz.) packets on opposite sides of the ball, 6-8" deep.
   3-5' and specimen - 3 to 4 (1 oz.) packets 6-8" deep equally spaced around ball.

5. After placing plants, fill bed with prepared soil mixture. Tamp soil in and around plants.

F. Ground Cover Planting

1. After removal of soil from ground cover beds and preparation of base, backfill with prepared soil mixture.

2. Apply fertilizer to bed surface at rate of 30 lbs. per 1,000 square feet and lightly rake into top 3 inches of soil.

3. Cover beds with 2 inch depth of mulch.

4. Remove ground cover plants from pots with roots intact, insert in mulch and plant in soil at same depth at which they were grown, at spacing specified. If balls are rootbound, score on four sides with sharp knife or other sharp instrument and flare out the four quadrants on the lower third of the ball to prevent a girdled root system.

G. Do not pull burlap from under plant ball.

H. Do not leave air pockets around plant ball.

I. Shape backfill into a saucer with diameter equal to that of planting pit. On slopes, build backfill up on lower side only, to catch and hold water.

J. Water plants immediately after planting, fully and thoroughly saturating all backfill in pits and beds on day planted. Apply water only by open end hose at very low pressure to avoid creating air pockets and injury to roots. Plants must be vertical. Take care to avoid foot traffic across areas which have been planted.

K. Mulch within 24 hours after any planting. Apply uniformly to cover saucer areas of individual plants and surface of shrub beds to loose measurement depth of 3 inches. Pull mulch 3-4" away from trunk and stems. Apply finish coat of mulch on ground cover beds as necessary to cover soil and achieve a depth of 2". Water mulch thoroughly after placement.

L. If planting occurs during season when deciduous plants are in foliage, spray both deciduous and evergreen plants with antitranspirant as specified. At other seasons when transpiration rate

is high, spray evergreen plants with antitranspirant. Method and rate of application must be in accordance with manufacturer's recommendations.

M. Prune at time of planting with due regard to natural form and growth characteristics of each species. Method and amount of pruning will be determined by Project Landscape Architect or Horticulturist.

3.03 PLANT SUPPORT

A. Wrap trees by overlapping one half the width of the material. Wind from base of tree to lowest main branches. Tie wrapping at top, bottom and at 1-foot intervals along trunk with twine. Wrap within 2 days after planting, but not before condition of trunks has been inspected and approved.

B. Guying

1. Guy all trees above 3" caliper at points of branching with three wire guys attached to specified 4' x 2" x 2" stakes driven at equal spaces into the ground outside tree pit, leaving a uniform height of no more than 9 inches of exposed stake. Paint stakes with dark brown paint or stain approved in advance by Contracting Officer.

2. Cover guy wires with either black or dark green rubber hose to protect bark at points of contact. Use only one color throughout project. Tie an 8-inch length of white vinyl flag midway on each guy wire.

3. Guy trees as soon as practical after planting, but within no less than 48 hours.

C. Staking

1. Support trees less than 3" in caliper by three 96" x 2"x 2" stakes driven at equal spaces around and outside perimeter of tree pit and to sufficient depth to hold trees rigid. Drive stakes vertically. Wire tree to each stake below first branch and midway to ground. Cover as specified for guy wires. Paint stakes with dark brown paint or stain approved in advance by Contracting Officer.

2. Stake trees as soon as practical after planting, but within no less than 48 hours.

D. Maintenance: Contractor must, until final acceptance, properly care for all plants furnished, planted or stored, performing such watering, weeding, cultivating or other ordinary maintenance work necessary to keep stock in a live healthy condition. Shrubs and trees which have died back into crown or beyond normal pruning line must be replaced by Contractor at no additional expense to the Government.

E. Cleanup and Restoration: Contractor must furnish all labor, materials and equipment for cleanup and restoration of all disturbed areas or features damaged during course of work. Contractor must replace all damaged sod to satisfaction of Contracting Officer at no additional expense to the Government.

CONVERSION FACTORS

LENGTH

1 foot (ft.) = 12 inches (in.)

1 yard (yd.) = 3 ft. = 36 ins.

1 mile = 5,280 ft. = 1,760 yds.

AREA

1 square yard (sq.yd.) =
9 square feet (sq.ft.)

1 acre (A.) = 53,560 sq.ft. =
4,840 sq.yds.

VOLUME

1 cubic foot (cu.ft.) =
1,728 cubic inches (cu.in.) =
7.48 gallons

1 cubic yard (cu.yd.) =
27 cu.ft.

LIQUID

1 tablespoon (tbsp.) =
3 teaspoons (tsp.) =
0.5 fluid ounce (fl.oz.)

1 cup = 8 fl.oz. = 16 tbsp.

1 pint (pt.) = 2 cups

1 quart (qt.) = 4 cups =
32 fl.oz.

1 gallon (gal.) = 4 qts. =
8 pts. = 128 fl.oz.

WEIGHT

1 pound (lb.) = 16 ounces (oz.)

1 ton = 2000 lbs.

1 gal. water = 8.33 lbs.

1 cu.ft. water = 62.31 lbs.

1 cu.ft soil = approximately
100 lbs.

RATE

1 mile per hour (mph) = 88 ft.
per minute = 1.467 ft. per
second

1 lb. per 1,000 sq.ft = 43.56 lbs. per acre
(use 44 lbs. for pesticides or 50 lbs.
for lime and fertilizer)

1 ton per acre = 45.9 lbs per
1,000 sq.ft. (use 50 lbs.)

1 qt. per acre = 4.2 oz. per 1,000 sq.ft.

FERTILIZER

1 lb. nitrogen per 1,000 sq.ft.
= 10 lbs. 10-x-x
= 8.3 lbs. 12-x-x
= 7.1 lbs. 14-x-x
= 6.2 lbs. 16-x-x
= 5.0 lbs. 20-x-x
= 4.9 lbs. Sodium nitrate (20.5% N)
= 4.3 lbs. 23-x-x
= 3.2 lbs. IBDU (31% N)
= 3.1 lbs. SCU (32% N)
= 3.0 lbs. Ammonium nitrate (33.5% N)
= 2.6 lbs. Ureaform (38% N)
= 2.2 lbs. Urea (46% N)

TEMPERATURE

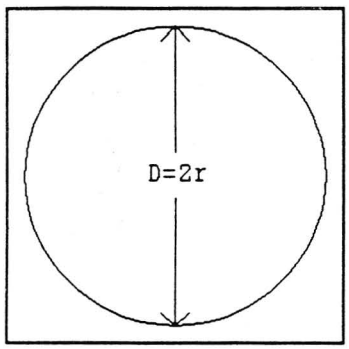
Celsius (C) = 5/9 x (degrees fahrenheit - 32)

Fahrenheit (F) = 9/5 x degrees C + 32

CONVERSION FOR SMALL AREAS

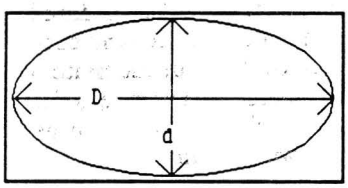
Rate Desired	Pounds per Gallon in Formulation					
	1 lb.	2 lb.	4 lb.	1 lb.	2 lb.	4 lb.
	Amount of Product to Use					
	Quarts/Acre			Tbsp./1,000 sq.ft.		
1/3 lb./A.	1-1/2	3/4	3/8	2-1/4	1-1/8	9/16
1/2 lb./A.	2	1	1/2	3	1-1/2	3/4
1 lb./A.	4	2	1	6	3	1-1/2
1-1/2 lbs./A.	6	3	1-1/2	9	4-1/2	2-1/4
2 lbs./A.	8	4	2	12	6	3

CALCULATING AREA



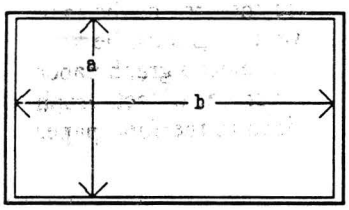
Circle

$A = \pi \times r^2$
(π = pi = 3.1416)
Where D = 6"
$A = \pi \times 3^2 = 28.27$



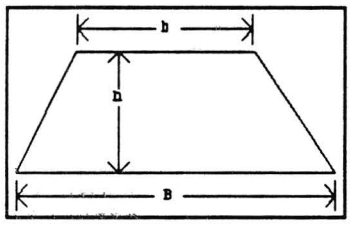
Ellipse

$A = \pi$ (½ D x ½ d)
Where D = 6, d = 4
$A = \pi \times 3 \times 2 = 18.85$



Rectangle
or square

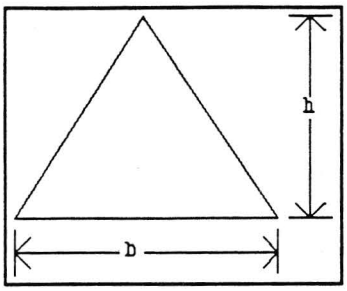
A = a x b
Where a = 4, b = 6
A = 4 x 6 = 24



Trapezoid

A = (b + B) ÷ 2 x h
Where b = 3, B = 5, h = 2
A = (3 + 5) ÷ 2 x 2
8 ÷ 2 x 2 = 8

Triangle



$A = \frac{1}{2} b \times h$
Where $b = 6$, $h = 5$
$A = \frac{1}{2} \times 6 \times 5 = 15$

Irregular Areas

The area of irregular parcels may be measured in at least two ways.

The irregular parcel may be subdivided into a series of regular shapes and the areas of these calculated and added together. An ell shaped parcel would be divided into two rectangles, the area of each calculated, and each added together to equal the area of the ell shaped parcel. The area inside a race track could be divided into a rectangle and two half circles. A close estimate of the area of the track or other curved parcel with parallel sides can be made by measuring the center-line length and multiplying it by the width. A 4-sided parcel with no parallel sides would be divided into triangles. In a pinch, this can be done on the field with nothing more than a tape measure, surveyors flags or string, and a fair eye for a right angle.

Another easy method is to over-lay a map or scale drawing of the area with a grid or graph paper, and counting the squares on the area to be measured. When a square is partially filled, either estimate how full it is and count those more than half full; or count every other partially filled square. Using this method the area of the map is determined in square inches and, using the scale, this is converted to square feet. Two things must be kept in mind in doing this: 1) the smaller the grid, the more accurate the results will be, and 2) select a graph paper with a grid which will be easy to work with. For maps with scales of 1 inch equals some number of feet, graph paper with 10 lines to the inch works well. If the scale is given as some fraction of an inch to the foot, paper with the same grid, or a multiple of it, would be easiest to use.

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