CAPITOL PARK TRAINING MANUAL

DESCRIPTIONS AND GUIDELINES FOR HORTICULTURAL PRACTICES

Presented by

University of California Extension at Riverside

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NOTE: Subsequent to the preparation of this report, legislation (SB 63, Strickland) signed into law by Gov. Arnold Schwarzenegger eliminated the California Integrated Waste Management Board (CIWMB) and its six-member governing board effective Dec. 31, 2009.

CIWMB programs and oversight responsibilities were retained and reorganized, effective Jan. 1, 2010, and merged with the beverage container recycling program previously managed by the California Department of Conservation.

The new entity is known as the Department of Resources Recycling and Recovery (CalRecycle) and is part of the California Natural Resources Agency.

For information about this document, contact the CalRecycle Office of Public Affairs by email at opa@calrecycle.ca.gov or call (916) 341-6300.

TABLE OF CONTENTS

SECTION I

SECTION II

TURF MAINTENANCE

TREE MAINTENANCE

SECTION I

This section of the manual addresses the descriptions of cultural practices and their importance in the Park maintenance program. Cultural practices include, but are not limited to, mowing, pruning, fertilizing, irrigating, and integrated pest management procedures. Cultural management practices must take into account the site conditions and the landscape materials that now exist in the Park. These latter elements include the soils, the irrigation system, irrigation water quality, and the established plants. An understanding of how cultural practices work with inherent features or conditions in the Park is a crucial component to a successful program.

Fertilization

Fertilization is a critical aspect of managing the landscape. Both primary, secondary, minor, and trace nutrients are necessary for the cultivation of healthy turf, trees, and ornamental plants. A vigorous plant, one in excellent health, will have the best defenses against invasion from weeds, insects or diseases. Applying the correct amount and type of fertilizer is a key element in successfully controlling maintenance costs and plant waste.

Fertilizers can be categorized as “quick release” or “slow release”. Fertilizers that are quick release promote excessive plant growth, which can translate to the production of green waste. However, their volatile mode of action means that their effectiveness is short-lived. Further, these materials are highly soluble, making them an environmental risk for both contamination of groundwater and off-site transport.

Capitol Park fertility programs should focus on slow release fertilizers. Categories of slow release fertilizers include natural organics, synthetic organics, and coated materials. The third category, coated materials, release at a slow rate because they are covered with sulfur or polymer coatings. The thickness and hardness of the coating, as well as the particle size, usually determine their release rate. External forces that

affect the release rate may be either moisture or temperature, or perhaps both. The goal of slow release fertilizers is to provide am even release of nutrition to the plant without spurring excessive growth.

Components in Fertilizers

There are several plant nutrients that have been determined to be essential for good turf health and growth. In some cases, the natural presence of these elements and nutrients causes them to be rarely mentioned in connection with fertilizers and soil fertility. Carbon is a good example. Although carbon is the primary building block for all life, it is seldom considered as part of a fertility program. While carbon is overlooked because of its seeming abundance, other nutrients are not considered for just the opposite reason. They may be required in only very minute amounts for healthy plant growth.

In reviewing plant nutrients, we should start with the primary nutrients mentioned above, nitrogen, phosphorous, and potassium. Fertilizer labels will always show the percentage of these nutrients in the bag. Additionally, they will always be in this particular order. The first, nitrogen, is the nutrient that propels plant growth. More of this material is generally applied than any other essential nutrients. Mostly, nitrogen is taken up by the plant in the nitrate form. Other nitrogen compounds added to the soil are converted to the nitrate form by soil organisms before being utilized by the plant.

The second primary nutrient listed, phosphorous, is present in all living cells. It is commonly known that phosphorous stimulates root growth. Further, it helps the plant to initiate early growth. Phosphorous hastens plant maturity, and promotes seed production. The insolubility of phosphorous in soils can limit its availability to plants. Therefore, on soil tests, phosphorous levels can deceptively appear to be very adequate, when, in fact, they are not.

The third primary nutrient, potassium, is needed in greater quantities than was earlier thought. While conventional wisdom was to apply nitrogen

roughly at twice the rate of the other two primary nutrients, many turf mangers now apply nitrogen and potassium in near equal amounts. Other than carbon, potassium may well be the most overlooked turfgrass nutrient in its importance. Like phosphorous, potassium also encourages root growth and development. More commonly known, potassium helps the plant build endurance and resistance to disease. It is essential in several internal plant functions as well. It is especially important to cell division and the transport of carbohydrates inside the plant.

The next group of nutrients is frequently the 'secondary nutrients". While they may often be secondary in the amounts applied, they are no less important to plant growth than the so-called "primary" nutrients. This group includes sulfur, magnesium, and calcium. An argument could be made for including iron and manganese as well. The first nutrient noted in this group, sulfur, is often though of as a soil conditioner, rather than a plant nutrient. This is because sulfur has the ability to alter soil pH.

The next secondary nutrient, magnesium, shares a relationship with potassium in much the same that that nitrogen shares a relationship with potassium. An increase in either magnesium or nitrogen calls for an increase in potassium. And while the reasons for this may be different, the cultural response is the same. One of magnesium's major effects on plant growth is its role in photosynthesis. Perhaps most importantly for turf managers is the fact that magnesium controls the color in plants. Turfgrass that is deficient in magnesium will not be as green as it would be otherwise.

Calcium, like sulfur, is also frequently considered a conditioner, as well as a plant nutrient. It is a major ingredient in both lime (calcium carbonate) and gypsum (calcium sulfate). However, its role in plant nutrition is very crucial also. A calcium deficiency impairs the plant's absorption and retention of other positively charged nutrient ions.

The last two nutrients tentatively added to the "secondary grouping", manganese and iron, also share a relationship. Manganese is an enzyme

activator and it assists iron in chlorophyll formation. However, high levels of manganese may induce iron deficiency. Besides chlorophyll formation, iron is important in other aspects of photosynthesis and plant respiration.

Several "minor" elements are important in plant growth. These include copper, zinc, molybdenum, boron, and chlorine. While these are important in minute amounts, some, like boron, can be toxic to plants at fairly low levels. Of course, the information presented in this manual is only the beginning of the entire subject. There is much more to be learned about the role of each nutrient, and the interaction between specific nutrients in the group.

Irrigation

Uneven or excessive irrigation creates rapid, but soft and succulent plant growth. Two factors of great importance come into play in irrigation scheduling. These factors are the *distribution uniformity* (DU) and *precipitation rate* (PR). Poor uniformity or unevenness of water application forces the turfgrass manager to accept either wet areas or dry areas. Since most managers seek to avoid dry and brown spots in the turf, an excess amount of water is applied in some areas when the uniformity is poor. Both the DU and the PR are inconsistent in the Park.

The precipitation rate refers to the amount of water applied to an area in given amount of time. It is important that similar sprinklers and valves apply an approximately equal amount of water in a specified amount of time. Otherwise, it is impossible to schedule irrigation run times with any degree of confidence. Both the DU and the PR can be measured by a catch can method that is explained in a University of California Cooperative Extension booklet. While Capitol Park irrigation systems have inherent limitations that are difficult to change, systems improvements can sometimes be simple and inexpensive. For example, raising and leveling sprinklers, and installing the correct nozzles can sometimes greatly improve system performance.

Irrigation Scheduling

The guidelines for irrigation scheduling take into account how effectively water is being applied to sites. As a practical measure, the lower the distribution uniformity the more irrigation run time is required to adequately water the poorest covered locations. In other words, with low system distribution uniformity some area will be over-watered in order to adequately saturate other areas. This is the reason that good uniformity is so critical.

Knowing precipitation rates for individual irrigation stations is critical as well. Precipitation rates are measured in fractions of inches of water applied per hour. For example, if one irrigation station applies 0.30 inches per hour and a second station applies 0.50 inches of water per hour, it makes little sense to schedule both stations for 15 minutes of irrigation time. For these reasons, in regards to irrigation scheduling, distribution uniformity and precipitation information is inextricably linked.

Irrigation scheduling and management will be based on several other factors as well. Different species of turfgrass, trees, shrubs, and groundcovers will have varying water requirements. These requirements are translated into a set of "crop coefficients" that are standardized for easier understanding and irrigation scheduling.

Consideration will be given to run-off potential from irrigation. Soil infiltration rate must exceed the precipitation rate or water will move from the irrigated areas. Therefore, the incline of sites, in combination with the soil infiltration rate, will be a determinant when scheduling irrigation. Of special concern at the Park is when there are drains that carry water off-site. Under these circumstances, there is the potential for transport of water-soluble fertilizers and pesticides.

Irrigation Water Quality

A thorough understanding of irrigation water quality is very important to the successful management of turf and landscapes. Understanding such major water quality factors as pH, nutrient content, alkalinity, salinity and the concentration of elements and compounds toxic to plants is crucial when developing cultural practices programs. Information regarding irrigation water quality is also very important when selecting turf species for the site. Fortunately, water quality is relatively good at the Park. However, an understanding of water quality issues remain important.

While testing the soil for information in the above-mentioned areas is common practice, testing of the irrigation water is frequently overlooked. Actually, soil and water quality testing go hand in hand. Soil acts as filter or sponge, trapping the negative elements in the water in upper inches of the soil profile. Irrigation water does one of three things when applied to a turf site – evaporate from the soil surface, percolate through the soil profile, or is utilized for plant growth. In all of these cases, many of the undesirable elements and compounds are left in the root zone of the soil profile.

Repeated applications of poor quality irrigation water can eventually raise the concentration of these unwanted elements to levels that are toxic to the plant. This is especially true where the soil drains poorly or is already high in salts or other negative materials. So in addition to a nutrient and chemical analysis, it is valuable to do physical testing of the soil to determine soil particle size and distribution. The physical analysis will also estimate infiltration and percolation rates. This information helps tremendously in deciding the type and quantity of soil amendments, as well as the necessity of installing drainage systems in the turf and landscape areas. Soils that drain well allow for the undesirable elements to the leached or rinsed from the soil through the application of additional irrigation water.

Irrigation water testing results can be matched to a chart that categorizes concentrations of different materials. A text entitled Salt-Affected Turfgrass Sites-Assessment and Management by R.N. Carrow and R.R. Duncan is an excellent reference. It is available through both the Golf Course Superintendents Association of America in Lawrence, Kansas. The book deals extensively with both soil and water quality issues and their relationship.

Looking at the different analyses derived from irrigation water testing, the pH reading is a measurement of the degree of acidity or alkalinity of the water. The pH is measured on a scale of 0 –14 with a neutrality level of 7.0. Problems with pH extremes in the Southwest are almost invariable from readings on the high or alkaline side. The number measurements for pH are logarithmic, meaning that each number represents an increase in concentration of 10 times the previous number. In other words, 8.0 is 10 times greater than 7.0, and 9.0 is 100 times greater than 7.0 in terms of alkalinity. The same is true with acidity, 6.0 is 10 times greater than 7.0, and so on. Extremely high pH, our primary concern, can be reduced if necessary. The primary method of achieving pH reduction of irrigating for large turf areas is through the injection of sulfuric acid.

An important category to note on an irrigation water sample report is the level of sodium and total salts. Sodium is listed separately from other salts because it has the ability to destroy soil structure as well as impact the health of the plant. Sodium concentration is listed as milliequivalents per liter. The sodium risk can be greatly buffered by concentrations of calicum and magnesium in the water. The comparison formula is called the *Sodium Absorption Ratio,* and the lower the number the better.

Total salinity can be listed as either *Total Dissolved Salts* (TDS) or as *Electrical Conductivity* (EC). If listed as TDS then divide by 640 to find the EC. If EC is listed, then multiply by 640 to find the TDS reading. Salts from irrigation water can accumulate in soils and cause a condition detrimental to plants called “physiological drought”, where water is present but unavailable to the plant. The rule of thumb is that an

additional 12.5 percent of irrigation water is required for each 1.0 elevation in EC to provide for adequate leaching of salts from the soil profile. Salt tolerance levels vary greatly with different turf species. Knowing the salt levels in irrigation water can be tremendously helpful when selecting a turf species for a particular site or facility.

Carbonates and bicarbonates are other detrimental compounds in irrigation water. Their presence is frequently in association with high alkalinity. Reducing the pH in extreme situations will also have the benefit of offsetting the effects of carbonates and bicarbonates. Testing the water to determine the levels of these and other compounds listed above will be a great advantage in the quest for healthy turf. As mentioned earlier, while the information is more academic than applied practice at Capitol Park, it is imperative that landscape managers understand water quality implications.

Pruning

Proper pruning protects the health and appearance of trees. Practices such as topping and stub cuts create hazards and lower the tree's value. These practices should always be avoided. Following the International Society of Arboriculture (ISA) guidelines will increase the health, beauty and value of trees. In the long run, correct pruning also reduces pruning time required and greenwaste generated.

If a tree is pruned correctly when young, it will need fewer and less drastic cuts as it matures. Young trees must be pruned the first few years to develop a sound, well-balanced branching pattern. Pruning should promote the basic framework of the tree that will be built upon as the tree matures. Between prunings, inspect for broken branches, injury and diseases. Fast growing varieties, like eucalyptus, those with a weeping form, such as Willow, and those that sprout easily, e.g., Brazilian pepper, need more frequent pruning. Some trees, like Pine, require very little pruning. Remember that these are guidelines to create "natural" looking trees. Unnecessary pruning is a waste of time and money, and can seriously damage trees.

Composts

Compost versus Mulch

Compost is a "cured" greenwaste product that has been decomposed and stabilized through biological decomposition. A good compost product is one where weed seeds and pathogenic organisms have been rendered neutral. Composts improve the structure and nutrient holding capacity of soil.

By contrast, organic mulches generally are not decomposed. These materials usually serve as a soil cover, but they may be incorporated into the soil profile. Mulches do have a role in the park maintenance program. They improve the appearance of the landscape, help retain soil moisture, and they aid in weed suppression. However, they are not recommended as an outlet for greenwaste generated at the Park.

Mulches made from greenwaste accumulation at the Park have had poor acceptance in the past, due largely to their instability and inconsistency. Since these particular materials are also biologically unstable, their decomposition may actually deplete the soil of nitrogen, the nutrient needed in the largest quantities for plant growth. Their continuing decomposition may create other problems as well, such as being unworkable or having an unpleasant odor. These unpleasant side-effects of mulch made from park greeenwaste do not apply to commercially prepared mulches.

By definition, "organic materials" must have a carbon base. However, it must be understood that these carbon base materials vary widely in origin and quality. Organic amendments preferred for use in Capitol Park are of plant origin and have gone through a composting process. These organic compounds are quite stable, of good quality for the purpose they are used, and they are slow decomposers.

The other organic materials that we see used as soil amendments or plant fertilizers are of animal origin. They are much quicker to decompose, and are usually higher in fertility, than the plant materials. These products often come from sewage sludge, bone meal, and blood meal. While these materials have a place in soil and plant fertility programs, they are a poor choice as soil amendments.

Organics are a wonderful supplement. They increase the moisture holding capacity of the soil. The organic particles provide "sites" for fertilizers to reside until plants can take them up as nutrients. The organic particles also act as a filter to keep fertilizers, pesticides, and other contaminants from leaching into the groundwater supply. At the same time, porosity of the soil is increased, providing a better balance between air and water. Organic matter adds beneficial organisms to the soil profile as well. These organisms play a vital role in converting fertilizers into compounds that are easily absorbed by plants. Overall, an organically amended soil is healthier, more resilient, and becomes a pleasure to till or work with your hands.

In addition to the benefits already mentioned, organic materials add micro nutrients and trace elements to the soil that are usually not included in commercial fertilizer formulations. Further, it has been shown that adding organic matter reduces the incidence of plant disease. Work continues in this area to try and determine exactly what properties of organic matter reduce disease outbreaks. Companies want to develop commercial products that "mimic" this natural disease suppression. This is not easy since each situation is somewhat different and soil temperature, moisture content, and plant selection all play a part in the process.

The question becomes how much organic matter should be added Capitol Park soils. Sandy soils usually have a minimum organic content. Organic percentage can usually be safely increased to at least 20% of the total soil mix. Keep in mind that organic amendments are lighter and

fluffier than sandy soil. So if you add one inch of amendment on top of the ground and till to five inches for a lawn installation, you will still have added something less than 20% to the new soil mix. On a cautionary note, roots do not like to grow in two separate soil mediums. So if you blend the amendments only 3 inches deep, it is likely the roots will not go any deeper than that.

Physical Standards of Composts

The compost should have a pleasant aroma and be consistent throughout. For easy utilization and acceptance at the park, particle size should not exceed one inch in diameter. If the compost is to be used as a turf topdressing, the finished product will need to be even finer in texture. The bulk density of the compost should be in the range of 800 to 1200 pounds per cubic yard. Ideally, the moisture content should be between 40 and 50 percent, but a somewhat wider range is acceptable. Organic matter content should be a minimum of 50 percent by weight.

Composts Chemical Composition Standards

The absence of feedstock derived from animals (manure) offers some advantages in terms of lower salinity. Total dissolved salts for plant applied compost should never exceed a electrical conductivity (EC) of 4.0 mmhos/cm, and should preferably be less than 3.0 mmhos/cm. A downside of the lack of animal based organics in composts is a reduced nutrient content.

The carbon to nitrogen ratio for finished compost should be less than 20. If ratios are too high, nitrogen can be tied up in the compost and unavailable to plants. The pH value of finished compost should be neither extremely acidic or alkaline (5.5 – 8.0 pH). All information collected to date indicates that the above parameters are achievable for a composting program at Capitol Park.

Compost Utilization

There are multiple uses for a quality compost material within the Park. A considerable quantity of compost can be incorporated into defined areas of exposed soil beneath trees and shrubs. The rich compost will enhance the appearance of these areas, as well as greatly improve the quality of the existing soil. Compost applications can be mixed with the soil in these locations annually for several years. Amending the soils with composted organic matter is both practical and environmentally sound. Water and fertilizer will be conserved and the plants will be healthier. Because organic matter binds the soil and makes it more absorbent; runoff, erosion, and chemical leaching will all be reduced.

Soils

When planting turf, trees, shrubbery, or groundcovers, the environmental component over which we have the most control is the soil. Fortunately, in addition to being the most manageable element in a planting program, soil is also the most important. Success will be highly dependent on how well we have prepared the growing medium, namely, the soil. Although Capitol Park soils are not especially problematic, almost all soils can be amended to improve plant growth.

But before we can change a soil for the better, we need to have some understanding of its composition. Generally speaking, soils can be separated into four basic categories of constituents. They are mineral matter, organic matter, air, and water. The mineral content constitutes the major component of the soil. In fact, soils are largely made from the weathering and subsequent deposition of rock material in the form of sand, silt, and clay.

Sand is the largest of these three types of soil particles and its predominant composition is the mineral, quartz. Soils high in sand are desirable because they drain well and do not compact easily. The down

side of sands is that they need more frequent watering and have limited nutrient holding capacity.

The next particle type and size is silt. It is in the intermediate range between sand and the smallest particle group, clay. Unlike sand, the water retention capability of silt is quite high, and it is prone to compaction under heavy traffic conditions. This tendency to compact under vehicular or foot traffic makes it especially undesirable as a soil for lawns.

The final type of soil particle is clay. It is many times smaller than the sand and silt fractions. However, clay particles have a very large surface area relative to their size. They have an extremely high rate of water retention, but the water often is not available to the turf and other plants. Clay actually swells to a greater size when wet and shrinks when it is dry. Surface cracking on dry soils indicates a high degree of clay.

Clays are also easily identified in soils because of their cohesiveness and their "plasticity", meaning that they stick together and can be easily molded into different shapes. How well a hand full of soil holds together when squeezed into a ball is indicative of the percentage of clay in the mix. Another easy test is to put the soil into a closed jar of water and shake it vigorously. After the solution sits for some time, the clay will settle out on top.

Although clays have a very high nutrient holding capacity, they are generally undesirable in any large degree. They can greatly impede soil drainage and are even more prone to compaction than the silts. They swing from soaking wet to bone dry, seemingly without any happy medium. Even when a clay layer is several inches deep in the soil, it can harden and impede drainage.

In addressing the air and water soil components, the pore space in soils should be about evenly divided between the two. The balance between air and water moves up and down with the amount of rain and irrigation. The water to air ratio stabilizes when only the water is left that does not

drain from gravity flow. The amount of water that has resisted the pull of gravity to stay in the soil profile is referred to as the "field capacity". This balance between air and water is critical to both plant health and the workability of the soil.

The organic portion of the soil is composed of both living and non-living matter. The living organic material is largely from bacteria, fungi, algae and other microorganisms. But it can also be larger organisms, such as earthworms. The microorganisms, bacteria in particular, play a vital part in chemical changes in the soil solution. The decomposition of organic matter and the transformation of nitrogen to a form useable by the plant are dependent on these organisms.

The non-living organic component in the soil is mostly from decomposed plant material. Soils high in organic matter form a very good growing medium. Most commonly occurring mineral soils, including those at Capitol Park, have very low organic matter content. This is where we have an excellent opportunity to improve the soil. The term "rich" soil refers directly to the organic content of the soil. As an example, if we estimated a soil to be around one percent organic, then we can safely increase the organic matter content by twenty-fold.

Although the texture of sand, silt, and clay soils is very different, *adding organic matter is the best way to improve the plant environment in all types.* It dramatically helps sandy soils hold water and nutrients. Not only is water conserved, nutrients end up in the plant and not in the groundwater. Organic matter greatly improves clay and silt soils by creating pore space. Poor water absorption and drainage problems in these soil types are also alleviated by incorporating amendments.

Sometimes sand is incorrectly added to clay soil in an effort to improve it. A huge amount of sand is required for this method to be successful. A small amount of sand additive will actually make the problem worse, by creating a sort of cement solution. We are looking to change the *structure* of the soil, not the *texture*.

As described earlier, the organic matter we want to add to the soil is composted plant material. Amending soils with composted organic matter is both practical and environmentally sound. Water and fertilizer will be conserved and the plants will be healthier. Because organic matter binds the soil and makes it more absorbent; runoff, erosion, and chemical leaching will be reduced. Additionally, the use of compost diverts plant waste away from landfills, where it has traditionally ended up.

Using Edges and Borders at the Park

The purpose of a border or edging material is to separate different areas in the Park. These areas will usually contain different types of plant materials. As examples, turf may be separated from annuals or groundcovers or trees may be separated from shrub beds. Edging materials are most important as a practical measure when a plant species, such as bermudagrass, is extremely aggressive and prone to encroachment into other areas.

Aside from the practical considerations of separating planting zones, edging can be very attractive. The human eye likes to see clean lines that move in slow, sweeping contours. As a matter of fact, the lack of clean, sharp lines in a landscape is a quick indicator that the maintenance is lacking. Of course, without some sort of hard edging material to work to, these lines are very hard to maintain.

Hard surface bordering or edging materials come in many forms. Concrete, wood, asphalt, plastic and aluminum, brick, and paving stones are all commonly used. The quality, cost, permanence, and difficulty of installation vary widely between these numerous materials. Predictably, the cheapest materials are the easiest to install and have the shortest life span. "Bender boards," and similar looking plastic edging that comes in roles, are very low priced and can be installed by almost anyone. However, do not expect these materials to last a long time. All the same, they have a place in the landscape market and they are certainly better than no edging at all.

Heavier wood materials and stronger plastics that do provide good quality and a long last edge are also available. But for a truly classy look that also works well for the maintenance staff, consider using concrete, brick, or stones. These borders add a sense of elegance to the landscape and they are certainly permanent. Although having said that, narrow and subtle are better than wide and obvious. Even with attractive (and more expensive) materials, the goal is still to separate different areas and to make mechanical edging and clean lines easier to achieve.

The amount of work required to keep edges looking good depends largely on the plant species used in those areas of the Park. Warm season species of turf that spread by runners or stolons require a great deal of edging in the summer. This usually means weekly, or at least every other week. Burning back the edges with a herbicidal acid or desiccant will reduce maintenance, but applying discretionary chemicals at the Park is not recommended. On large plants, periodic pruning may be needed to keep limbs inside the designated area. In other case, sweeping or washing along the edging is all that is needed to keep the different zones clearly defined.

There are companies now in the landscape market that do nothing but install edging. A special machine is used to form and lay a concrete edge. The enterprising landscape manager can also form for concrete borders with bender board or similar material. Similarly, semi-skilled workers can use mortar mix to lay a brick or stone border. After all, this type of work does not require the precision and expertise one would need to build a brick or stone wall. Remember however, these borders or edges are meant to be helpful, but subtle, additions to the landscape, and not prominent features.

The appeal of borders can be enhanced by the emphasizing contrasts in color. Rich, brown bark in a planting bed can accent the edging and present a vivid contrast to turf or other neighboring plant materials.

Although less practical as a separator or border, plant materials can also be used to define landscape areas. With the possible exception of hedges, plant materials used as borders are much more for appearance than practicality. Almost any compactly growing plant can be used in these designs. Perennial and annual flowers are often used as borders. Even miniature roses fit the bill in certain situations. Small, flowering shrubs that have fine textured leaves are popular for borders as well. Occasionally, narrow rows of turf are used as borders, but they are exceedingly difficult to maintain.

In summary, edging and bordering are helpful, attractive additions to the Park. It is best when it is not overdone. Consider your goal before deciding on what type of material to use. Each situation is unique. The right choice will make for a terrific presentation and easier maintenance.

Greenwaste Reduction

Reducing organic waste generated from on-going landscape maintenance is closely tied to correct cultural practices. Examples of green waste generated from routine maintenance include mower clippings and tree limbs and leaves that result from pruning practices. Since mowing is the most prevalent maintenance procedure and a major producer of green waste in the Park, a larger focus must is placed on sound turfgrass management practices.

In addition to mowing and pruning, cultural practices employed at Capitol Park include fertilizing and irrigating, as well as periodic or seasonal maintenance, such as aerifying and overseeding. Adjustments to management programs in any of these categories have the potential to reduce green waste production.

Reduction of green waste through good management practices frequently enhances the health and vigor of established plants, provides economic benefits, and helps to protect the environment. Even the most thorough and efficient landscape manager can usually find additional ways of reducing green waste.

Grasscycling

Grasscycling is the process of returning grass clippings to the turf canopy at the time of mowing. Many mower and mower blade manufacturers have developed decks, screens, and blades to finely chop clippings into a consistency that allows them to be easily returned to the lawn without any unsightly brown clippings left behind. The grass clippings are not collected but instead returned to the soil in the same area of the mowing activity. Capitol Park is using riding mowers that have front decks with grass cycling capability. Grasscycling will be successful if performed in tandem with other recommended cultural practices such as appropriate fertilizer type, application rate and timing, watering schedules, irrigation uniformity, and mowing frequency and heights.

Trees

Benefits of Trees

Trees create a natural beauty and inviting setting in the landscape. They also perform some important roles in the protection and quality of our environment. Trees help offset high temperatures in urban areas where concrete, asphalt, and rooftops give off enormous amounts of heat. Trees reduce air pollution by absorbing several different pollutants and utilizing the carbon in carbon dioxide. Further, trees reduce erosion and urban storm water runoff. In Capitol Park, trees collectively form an extensive and historic arboretum.

If properly selected, planted, and subsequently cared for, trees are for a lifetime. Unfortunately, the general hardiness of trees sometimes causes the public and even landscape managers to take their health for granted. Ironically, the damage done to our landscape trees usually come more from our maintenance practices than from neglect. This is especially true when the area beneath the trees is a well maintained lawn or other turfgrass. In fact, the turf managers who take great pride in his lawn may

see the tree as a hindrance to his maintenance program, rather than an integral part of a beautiful landscape.

How trees grow

Roots – anchor the tree, transport water and food to the tree and they store food for the tree. Most roots grow in the top 40-centimeters of soil. They can spread out one and a half times the width of the tree's canopy.

Stems – can be called the shoot, trunk, twig, branch or limb. Stems support the plant and carry water and nutrients from the roots to the plant's growing points (buds, leaves, and flowers). They also carry food (sugars) that the leaves make to the roots. Stems are made up of thousands of tubes just inside the bark of the stem. Palm trees have tubes throughout the trunk areas. Because stems are conveying tubes, if you cut off a stem it will divert the flow of nutrients to other buds and branches.

Buds – develop along the stems and open to produce the first true leaves. End buds help the plant to grow taller; side buds produce leaves or more branches. You can direct the plant's growth by removing buds, which will channel energy into other buds.

Leaves – are the food factory of the plant. Leaves manufacture sugars and other foods from sunlight, air, and water that are supplied by the roots.

Flowers and Fruit – all plants form flowers, but not all flowers are noticeable. Flowers produce seeds, which reproduce the plant. By removing seeds (fruit) before they mature you can improve the tree's vigor.

Cool Season Grasses

Ryegrasses

A tremendous amount of research has been done with respect to perennial ryegrasses. There are now literally dozens of improved varieties from which to choose. Thanks to aggressive breeding and selecting programs, these grasses are more durable, pest resistant, drought tolerant, and wear tolerant than in the past. They are also greener in color and finer in texture than their parent plants. In local climates that are not extremely hot and windy in summer, ryegrasses have the color, texture, and density to be "showcase" lawns. Most other grassses cannot achieve the intensity of color that the ryegrasses can.

Interestingly, much of the breeding improvements done on perennial ryegrasses was to improve their marketability as temporary grasses. Millions upon millions of pounds of perennial ryegrass have been sold in the Southwest as a winter overseeding cover for Bermudagrasses. Ironically, the increased hardiness bred into these grasses for the overseeding market is now making them undesirable. Where the old varieties used to die easily in the spring from heat and Bermuda competition, the newer varieties can be found competing with Bermuda well into August. Their survivability is especially impressive in the California and Arizona low deserts, where August temperatures can reach 120 degrees.

Fescues

The fescues can be a confusing group of grasses from which to choose. Fescues can be loosely defined for the marketplace into three groups, "fine", "medium", and "tall". The fine fescues were once popular in overseeding mixes. However, with the vast improvement in perennial ryegrasses, the fine fescues quickly fell from favor, although they do remain popular in commercial lawn mixes. The best known of the finer fescues is "creeping red" (*Festuca rubra*).

The medium turfgrass fescues were substantially improved several years ago and are now popular lawn grasses in many areas of the Southwest. The medium fescues are fairly coarse in texture and lighter in color than some of the other cool season grasses. However, they are reasonably

heat tolerant. They also hold their color well in the winter if there is a minimal amount of frost.

The tall fescues have been around for a very long time. However, the original turf-type fescue is very substandard according to the quality measurements of today. It has coarse texture, a poor color rating, and poor density. Although originally marketed as a drought tolerant species, it also has relatively poor drought tolerance. Fortunately, new grass varieties have been derived from the original tall fescue. These varieties are referred to as the "dwarf tall fescues". As the name implies, they do not grow as tall as regular tall fescue, allowing a much lower mowing height. Their color is darker and their texture is much finer as well. The dwarfs are a much better choice than the original tall fescue.

Bluegrasses

The improved bluegrasses varieties are equally worthy of consideration as either as a mono-stand or in a seed mix. The older varieties of bluegrasses were very susceptible to disease infestation. They also needed to be mowed at a height that was unacceptable for many sports applications.

Relying on conventional thinking that cool season grasses will not work on a particular site or in a particular climate may be a missed opportunity. All of the grasses mentioned above are dramatic improvements over their predecessors. A little research into improved varieties will be well worth the time and effort. The older varieties of all these cool season grasses can be found at Capitol Park.

Warm Season Grasses

Bermudagrass

Bermudagrass is the primary turf for lawns, parks, golf courses, sports fields, along with many other recreational and practical applications in the hot, arid regions of the west and southwest. The warm Sacramento

summers make it a prevalent turf at Capitol Park. Although disparaged by gardeners and others who must remove this grass from flowerbeds and other areas where it is unwanted, common bermuda (*Cynodon dactylon),* has been a reliable choice for turf managers for many years. However,as demands for quality turf has risen, common bermuda has been joined by numerous other bermudas.

About four decades ago, the hybrid bermudagrassess began making an appearance into the turf market. Two of the early and popular hybrid cultivars were developed in Tifton, Georgia and were named Tifgreen and Tifdwarf. Hybrid bermudas are a cross between Common and a second species from the *Cynodon* genera. Since hybrids are of mixed origin and do not produce a viable seed, they must be planted either by stolons or sod. But their low growing habit, fine texture, durability, and evenness in appearance make them excellent choices for situations requiring high quality, short cut turf.

More recently in the turfgrass industry we have seen the development of "improved" seeded Common varieties, with names such as Cheyenne, Guyman, New Mex Sahara, and Sonesta. While there is no doubt that research will continue with these grasses, currently their growth habit and texture lies somewhere between Common bermudagrass and the finer leafed hybrids. Their advantage over the hybrids is their relatively easier and cheaper establishment through seeding.

As turfgrass quality falls under closer and closer scrutiny from Park patrons, the intensity of maintenance of these grasses increases. The importance and frequency of all cultural practices intensifies; including mowing, verti-cutting, fertilizing and irrigating. Additionally, bermudagrass that needs to have an attractive winter appearance, or is under heavy use, will frequently be overseeded in the fall with either annual or perennial ryegrass.

This intense level of maintenance, in conjunction with overseeding, can put a tremendous amount of stress on the bermuda. In fact, to the

astonishment of many turf managers, the grass we once though was indestructible, is not.

Realizing that while intense maintenance can greatly improve the usability and appearance of bermuda turf, such attention can be a double-edged sword. Probably the major culprit in loss of bermuda vigor is the overseeding. Fall preparation for overseeding disrupts the plant's storage of carbohydrates that will help it break dormancy in the Spring. Mechanical renovation, and some growth retardants that discourage bermuda fall resurgence, can further inhibit transition. Additionally, it has long been believed that ryegrass emits chemical agents (called allelopathic compounds) that discourages bermuda competition and its subsequent re-establishment.

Knowing that cultural practices can do as much harm as good should make us especially diligent in our maintenance methods. High fertility and frequent irrigation can cause an excess of thatch development, which in turn can dictate that extra verti-cutting be done. Well fertilized, overly moist turf can also lead to an increased incidence of pest infestation and disease. In cases where pests are inherent to the site or soil, such as with parasitic soil nematodes, populations can expand rapidly when there is excessive plant growth. Of course, these conditions pertain to any highly maintained turfgrass, not just Bermuda. Nematodes have not been proven to be a serious Park pest as of this writing. The same is true, however, of grubs – which are a significant turf pest on the Park lawns.

In regards to mowing, bermuda needs to be cut frequently to maintain a high quality stand. No more than one third of the top should be removed in a single mowing. A good rule is "the shorter the cut, the shorter the duration between mowings". Well manicured lawns probably should be cut twice, and certainly no less than once, a week. Waiting for long periods to mow bermudas, especially the hybrids, leads to a loss of density, consistency, and can encourage a host of secondary problems.

In summary, bermudas are great. They are highly adaptive to a variety of situations and they form an attractive, durable turf. There are certain

things, however, that must be understood before selecting bermudas. Most varieties will go severely off color when the temperature is consistently under 50 degrees at night, and they will go dormant where there is frost. They should be mowed with a reel-type mower for best quality, and verti-cutting needs to be done from time to time. They will not grow in shade. They will not "wear like iron". But they will thrive under proper care.

Pest Control Issues

Weed Control

The place to begin is with proper identification of the target weed species. However, there is a catch to this. If the weeds species are summer annuals they will not be present during the w inter when you are making final plans for a pre-emergent herbicide application. You will have to rely on memory for the type and degree of weed infestation that was in the turf last summer. Unless, of course, you had the foresight to take photos of the areas or keep good records of your observations.

Posting these photos or notes on a site map, letting you know when and where the weeds grow, will allow you to time the applications better and selectively treat only the spots where it is certain there will be an infestation. By choosing the right chemical it is also possible to achieve reasonably good control on seemingly diverse types of grassy weeds. For example, the winter annual Poa annua and summer crabgrass may both be on the same herbicide label with the same timing. Although rates may differ for control of each weed pest, as long as you choose the recommended rate for the more resistant species, control of the other targeted weeds should be fairly automatic.

Pre-Emergent Weed Control

Pre-emergent herbicides control weeds by killing the germinating seedlings as they attempts to emerge from the soil. A barrier is created in the soil through which they can not grow. As a note of warning,

aerifying and other disruptions to the soil surface should be ceased for the period of time the pre-emergent application is active to avoid damaging this chemical barrier. Usually a substantial amount of water is needed to activate the chemical ingredient and move it into the soil. The label will specify exactly how much irrigation water is required for this purpose.

If the infestation is heavy, it may take two or more years to reach an acceptable level of control. When the soil, climate, or other natural factors are beyond your control and favorable to weed development, you may have to determine whether treating every year with only limited success is worth the cost and effort. What you can do, however, is make certain that the cultural practices used at the turf site are not promoting weed development. Extreme maintenance methods are prime culprits in excessive weed infestation. Overwatering or underwatering, low fertility or extremely high fertility, low mowing or high infrequent mowing are all good examples of cultural practices taken to the extreme.

When choosing a pre-emergent, be sure to weigh the cost against the efficacy of the product. An expensive herbicide that promises complete control may not be as a good a value as one that provides 90 percent control for half the cost. Another factor to consider is the risk of herbicide toxicity to the turf. Paying a little more for a lower risk product may be good value in the long run. A third important factor is the longevity of the product. Does a single application give you control into summer, or must the product be applied twice. It is wise to write down a checklist of product requirements before beginning comparisons.

Make certain that the formulation of herbicide you choose is compatible with the equipment that is available to you. In other words, do not purchase a product that must be applied in solution if you do not have a sprayer. Several pre-emergents are now available in combination with fertilizer. A small rotary spreader is all that is needed to apply this material. Other examples of important considerations could be given but it is best to generate your own list by reviewing the situation at the treatment location.

SECTION II

This section addresses the cultural practices and site factors from an operational perspective. The information in the previous section focuses on the reasons particular practices and materials are used. Section II focuses more on the methods of instituting the cultural practices to the best advantage. The two sections are designed to be studied together. The understanding of the landscape management process is progressive. The "why" must come before the "how". Additionally, the nature of much of the material makes its placement in either of the two sections subjective.

TURF MAINTENANCE

Mowing

Mowing Equipment

Mowers are available in three basic styles. These are rotary, reel, and flail mowers. Generally, unless there are specific needs at a facility, rotary mowers are the popular choice. Fortunately, rotaries are usually the best choice as well. Rotary mowers give the best production in terms of turf area mowed in a given amount of time. They are also very versatile in terms of mowing height, terrain, turf density, maneuverability, and other related factors. This is the mower-style of choice at Capitol Park.

Rotary mowers operate work on the simple principle of a horizontal blade turning at a high rate of speed. This simple concept makes them fairly easy to maintain and repair. The amount of work they can accomplish also means a good return on the investment for the Turf and Landscape Manager. Rotaries come in a wide variety of models and sizes. Large, multi-deck rotaries that give both a fine cut and high

production come with a high price tag. But with good maintenance and operator care, these machines should last for a number of years.

Reel mowers are the next most common and popular type of mowers. Reel mowers are almost a necessity for low cut, fine textured grasses. This is particularly true where the grasses have a functional purpose, such as for professional football fields, golf greens and tees, croquet or grass tennis courts. Even lawns planted in bermuda hybrids or other fine textured, low growing grasses may require a reel mower.

Reel mowers are generally more expensive to purchase and maintain than rotary mowers. An experienced mechanic needs to be available for their proper sharpening and reel adjustment. Unless the selected turf variety requires reel mowing, reel style mowers are not recommended for Capitol Park. However, aside from costs and maintenance requirements, reel mowers still provide a superior cut to all other types of mowers. If it is important to leave a striping pattern on large turf areas, using reel mowers is the best way to do it.

Flail mowers are the third and least used style of mowers. Primarily, these units are used on long-cut grass that is often grown on rough terrain. Their method cut is the attachment of numerous small blades on fast rotating horizontal bar. Each individual blade is usually split and flared at the end for a wider cut. Flail mowers are useful tools for overseeding, or for thinning turf that has a heavy canopy. Flails can now be purchased as an alternate attachment to a mower that is primarily sold with a rotary deck Buying flails as attachments makes them a very reasonably priced addition to fleet of mowers.

Properly selecting maintenance equipment goes beyond production and grooming requirements. Quality equipment can actually protect the health of plants. Cleanly mown turf reduces the incidence of disease and insect infestations. Mowers that are easy to adjust in height reduce the possibility of cutting turf below where it can adapt and be healthy. Mowers that can cut large areas of turf in a short amount of time make it

easier for turf and landscape managers to schedule mowing of each site more frequently.

Mowing turf on a frequent basis is extremely important in the growing season. It is strongly recommended that not over one-third of the top growth be removed in any single mowing. Excessive foliage removal can severely shock a grass plant. If the cut is below the crown of the plant, the plant may die. Even with moderate height reduction from mowing, carbohydrate production and root growth stops for a period of time.

Carefully selecting maintenance equipment, particularly mowers, can have a much wider impact on maintenance operations and landscapes than initially thought. So plan carefully. Fortunately, manufacturers of mowing equipment provide options for all our mowing needs.

Mowing Frequency

Mowing cycles may vary from 5 to 14 days between cuttings, depending on turf variety and season. Mowing heights for turfgrass shall be adjusted to seasonal climatic changes to produce a healthier crop with a root system that requires less water. Mowing patterns shall be adjusted frequently to avoid creating ruts and compaction.

Turfgrass Selection

Choosing the proper turfgrass when planning a new lawn installation will greatly reduce future problems with weeds, insects, and diseases. A large percentage of these infestations and pathogens can be attributed to problems with poorly adapted turfgrass. Adaptation, in regards to turfgrass, refers to climate and site conditions, as well as to the functional use of the turfgrass.

Turf managers know that the best defense against weeds is a healthy, dense turf. Grasses that are ill matched to their site and use will soon decline in health and vigor. Weeds will encroach where there are voids

or a general lack of density in the turf stand. An excellent example is the frequent attempt to use bermudagrass when the site is a combination of sun and shade areas. While Bermudagrass is adapted to the region, it will not thrive in any degree of shade.

Lawns and other turf areas frequently have shaded sections from large canopy trees. It is common in these locations to see a pronounced line where good turf quality ends and grassy weeds begin. After all, it is perfectly logical that grassy weeds, such as *Poa annua,* will out-compete Bermudagrass when the conditions are more favorable for the undesirable grasses. Therefore, what was originally thought to be an obvious choice quickly becomes a management problem.

Shade, or course, is only one factor of the site environment that needs to be considered in turfgrass selection. Another example is high pedestrian or vehicular traffic on soils that compact easily. As compaction and wear combine to reduce turf density, shallow rooted, quick germinating weeds rapidly fill the voids. Weeds, like other pests, are opportunistic.

Insect problems are also closely associated with proper turfgrass selection. This is particularly true where cool season species of turfgrass are planted in hot, arid regions. Bentgrasses, bluesgrasses, and fine fescues are all examples of grasses that have a high susceptibility to insects and disease in warmer climates. Beetle larvae, or grubs, are one of the orders of insects that seem to prefer the roots of the cool season grasses. While their reduced vigor that makes them vulnerable to grubs, it also makes the grub infestation harder to diagnose. Grub damage is frequently misdiagnosed as inadequate irrigation, low fertility, or disease. As noted, grubs are an annual pest problem at the Park.

Poorly selected turfgrasses often require intense and specialized cultural practices. Ironically, it is often this intense level of management that leads to disease problems. This third category of pests discussed here, namely diseases, is probably the most critical of the three types of infestations. Diseases on cool season grasses in the summer can be swift

and devastating. Water borne fungi, such as Pithium, can literally wipe out a stand of turfgrass overnight.

Treatment for turfgrass diseases can be complicated and expensive. Turfgrass managers are often in the difficult position of risking the turf health by altering their cultural practices, such as reducing irrigation and fertilization. Applying expensive pesticides that require special applicator training document use and reporting is also a last resort alternative. The situation is further complicated by the fact that some disease conditions are aggravated by low fertility, while others thrive with high fertility. Sometimes multiple diseases are present in the same turf stand.

Turfgrass selection is frequently a decision made by the architect or planning committee. Turfgrass managers may find themselves accountable for the condition of turfgrass that is only marginally adapted to the site and circumstances. Under these conditions, it is the responsibility of the turfgrass manager to clearly define the problems associated with managing grasses that are not well adapted. Defining the problems before a crisis exists is much more credible than explaining why there was deterioration of the turf after the fact. At that point valid reasons may look more like excuses.

When the wrong grasses are selected, other limiting conditions are exacerbated. These so called "limiting conditions" may have been of minimal concern with the correct turfgrass, but they can be major problems with the wrong turfgrass. For instance, bermudagrass is tolerant of lower quality irrigation water but the more sensitive cool season grasses are not. The same is true for other cultural issues, including drainage, irrigation coverage, aerification, and fertility. There is a direct relationship between selection the proper turfgrass and; the costs of maintenance, the necessity of specialized procedures, and the risk of turf failure.

Selection Guidelines

The first consideration is whether it is to be an amenity turfgrass or a functional turfgrass. Amenity turf is essentially for appearance only. It is planted for aesthetic appeal and to improve the value of a given property. The importance of the proper selection of these "window dressing" grasses is not as great as with the functional use grasses. While climate, turf beauty, and maintenance demands certainly must be considered with amenity turfs, another entire set of selection criteria dealing only with functional use turf has been eliminated.

Besides fewer selection considerations, there is generally greater flexibility in the maintenance of amenity grasses. For example, although mowing height may be extremely important for highly specialized sports turf, such as golf course putting greens, it is probably only minimally important for a front lawn. The same is also true for turf density, texture, and resistance to wear – all factors which are very important in selecting functional turfgrasses. Flexibility for amenity turf also extends to the greater ease of scheduling maintenance, including special cultural practices such as aerifying and overseeding. Since Capitol Park turf must support numerous outdoor events annually, it must have both amenity and functional qualities.

Considerations that are important in both amenity and functional turfgrasses are the *adaptive characteristics,* the *management considerations,* and the *visual qualities.* The *adaptive* characteristics include drought and heat tolerance, cold tolerance, rooting capability, shade tolerance, moisture tolerance, and mowing height. Grasses that poorly adapt to site conditions will almost assuredly suffer from pest and disease problems. Adaptive problems are especially pronounced where poorly adapted grasses are planted next to well-adapted turf species. A good example is bentgrass on golf greens in the desert regions, planted next to hybrid bermudagrass approaches and collars. Diseases, insects, and weeds will all be considerably more of a problem on the cool season bentgrass than the much better adapted warm season bermudagrass.

Management considerations include yield and mow frequency, fertility requirements, and special cultural practices. While these considerations

do pertain to both amenity and functional turfgrasses, they are more important in the functional category. However, sports turf managers and others maintaining specialized, functional turf usually expects the management considerations to often be expensive and intense.

In terms of the *visual* qualities, the emphasis can be more on the amenity turf than the functional turf. This can be particularly true in regard to the turf color. In fact, color may not be a factor at all where function is concerned. However, turfgrass managers should be forewarned that observers use color, accurate or not, as an indicator of turf quality and condition. Other visual considerations, such as texture, uniformity, and smoothness can apply equally to either category.

It is the *use* characteristics that apply almost exclusively to functional turf. As mentioned earlier, density, texture and wear resistance are functional qualities. Also included in this group are such important factors as turf elasticity, resiliency, and recuperative capacity. Overlooking any of these considerations can lead to disappointing results. Unfortunately, turf selection decisions are often long since made when turfgrass managers assume responsibility for the site or facility. Therefore, when turf managers inherit grasses that do not meet the standard, they should make the management or owners aware of the turf's deficiencies. Turfgrasses lacking the qualities to perform well in specific applications should not reflect badly on the skills of the turf managers.

Selection Checklist

Desirable *USE* Characteristics

- ❑ Density and Uniformity
- ❑ Turf Texture
- ❑ Elasticity and Resiliency

- Recuperative Capacity

Desirable *ADAPTIVE* Characteristics

- Drought and Heat Tolerance
- Cold Tolerance
- Rooting Capability
- Shade and Moisture Tolerance
- Mowing Height

Desired *VISUAL* Qualities

- Color Shade and Intensity
- Texture and Uniformity
- Density and Smoothness

Management Considerations

- Disease Resistance
- Yield and Mow Frequency
- Fertility Requirements
- Special Cultural Practices

Irrigation Guidelines

When replenishing lost moisture through irrigation, there are two general philosophies. The first is short and fairly frequent watering cycles that

avoids water loss through run-off and keeps the plant from entering a stress phase. The second philosophy is to water infrequently but of longer duration. This method is commonly referred to as "deep watering". While both of these philosophies have their proponents, site specific considerations may make one method more practical than the other. There are numerous factors that need to be addressed when weighing the merits of each system.

Although it is not really the recommended choice in the two irrigation method options, short but frequent watering cycles may work the best in certain situations. Irrigating turf that is on steep slopes may cause the water to sheet off the inclining areas and puddle in the low spots when the sprinklers are left on for any period of time. Poor draining soils, or ones that are heavily compacted, sometimes makes deep irrigation impractical because the amount of water applied exceeds the soils ability to accept it.

Intensely managed turfgrass plots such as putting greens, grassed tennis courts, or lawn bowling facilities may need frequent watering; either because their appearance must remain spotless, or due to the sensitive nature of the variety of grass used. Further complication the situation is the commercial turf manager's often inability to return to the site more than once a day to see if the turf is under stress. When this is the case, then the practical solution seems to be option one, shorter and more frequent intervals of irrigation.

It should be understood that frequent, light watering is only the best option when the situation demands it. Sometimes it can cause secondary problems that will have a long term detriment to the turf and landscape. The resulting shallow soil wetting will keep the turf roots from anchoring deep in the ground. The same is true for the trees and shrubs, which generally do not like turf style irrigation even under the best conditions. Additionally, the frequent wetting and drying of the top inch or two of the topsoil with no rinsing effect, will allow salts and other negative elements in the water to concentrate in the root zone of the plants.

A good deep watering program, when the choice is possible, avoids most of the pitfalls of frequent watering. It promotes deep rooting by forcing the plant to reach for water. Although our primary focus is turf, it will also reduce the unsightly and dangerous surface roots of trees and shrubs. The extra volume of water partially cleanses the soil of concentrated salts and it promotes good soil structure by deep drying, followed by complete moisture saturation. By withholding irrigation until the need is obvious, there is an assurance that you are not overwatering. In fact, it is quite likely that a water savings will be realized.

Other advantages of deep irrigation include a reduction of grassy weeds such as crabgrass and Poa annua. Lawns that are heavily infested with crabgrass are almost invariably on a frequent and heavy irrigation program. Further, the incidence of disease is greatly reduced when the turf is thoroughly dried out between irrigation cycles. The grass tends to "harden off" under this type of management and will be stronger under use conditions and require less fertility to maintain a consistent look.

Knowing that deep irrigation is the best option, do not give up on it until you are certain that the site conditions cannot be amended to make it workable. For instance, only isolated areas may be drying out quickly, causing the irrigation scheduler to put in extra cycles. Instead, think in terms of adding small heads or amending the soil in these spots. Be creative, if the lawn is exposed to a prevailing wind, plant a hedge as a windbreak. The payoff will be worth it. Cutting costs, improving quality, and saving a valuable resource, namely water, are all keys to being a good turf manager.

Develop and maintain at least a 4 to 6 inch root depth for cool season grasses. Turf should receive deep watering to encourage a deep root system. Deeper turf roots use water more efficiently, decrease fertilizer needs, and increase turf's ability to withstand and recover from recreational use. Poor soil conditions, heat, and shallow watering practices all combine to shorten root development in turf.

Monitor watering and root depth with a soil probe. During irrigation, apply water to a depth that matches the desired root zone. Allow soils to dry to 50% depletion between watering. Soils that remain constantly wet kills off root tips and shortens roots. Watering deeply and infrequently encourages deep root growth that will wear better and be more drought tolerant than turf that receives water more frequently. Soil moisture levels and watering depth shall be checked weekly with a soil probe to ascertain the subsoil conditions. If a saturated condition is found, it is an indication of drainage problems or excessive irrigation applications and shall be reported to the grounds supervisor.
Regular weekly inspections of turf shall be made with a soil probe in conjunction with irrigation system inspections. Attention should focus on soil moisture, watering depth, and root growth. This will provide practical and useful data for adjustments to the irrigation system and for scheduling.

Irrigation schedules should be based on current climate conditions from CIMIS data and the water needs of the turfgrass variety. Match water application rates to soil infiltration rates to avoid run-off.

Turfgrass Appearance

The number one factor people use to determine if turf is in excellent condition is the color. Grass that is off-color, or inconsistent in the degree of color, will generally thought to be poorly maintained. Deep green is very pleasing to the eye. Looking for ways to achieve that deeper green appearance without spending a great deal of money can be interesting and rewarding.

The most obvious and accepted way of turning turf greener is through the applications of fertilizers high in Nitrogen. There is no doubt that this works. And nitrogen based fertilizers such as calcium nitrate and ammonium sulfate are relatively cheap to apply. The down side is that they will cause a rapid increase in the rate of growth, impacting the budget through higher labor costs.

However, there are other plant nutrients that will turn the turf greener without the high rate of growth. Applications of iron are the most popular method among western turf managers. At higher rates, iron provides almost an immediate darker shade of green. Depending on the formulation, the improved color can last from a few days to several weeks.

Iron applied to the foliage in solution with water is the fastest way to get a response. The iron formulation usually contains a small amount of nitrogen, along with several micro-nutrients. Chelated versions, those manufactured in combination with carbon, tend to last longer but they are also more expensive. Granular formulations, such as ferrous sulfate and Ironite, last longer but they should be watered in immediately after application. One should also be aware that many of these products, either liquid or granular, can severely stain concrete, tile, brick and other hardscapes. It is best to check the label and do a trial area first.

There are other plant nutrients that can have a positive effect on turf color. Zinc and magnesium to name two. Zinc is a common deficiency in many ornamental plants and is often applied in combination with iron. Magnesium is an integral part of the chlorophyll process and will provide a quick green-up if it is deficient in the plant. It can be very economically applied as magnesium sulfate.

A nearly cost free way of adding color to a lawn is to raise the mowing height. More height means more grass to attract the eye. Sound too obvious to mention? Apparently not. Most lawns are mowed below the optimum growing height for the variety of grass planted. Besides promoting a better stand of turf, the plant will be healthier and greener at its optimum height.

If the lawn in a serious state of decline, more extensive changes to improve the long term appearance may be in order. If serious renovation is required consider changing varieties. For example, change from a light colored fescue to a dark green perennial ryegrass. For turf that goes

dormant in cold weather, overseeding is a good option. Turf managers should concentrate their resources for the most important times.

As mentioned in the previous section, mowing and edging patterns should not be underrated. If a reel mower is being used, the lawn can be striped, giving it a very manicured look. If a particular pattern is desirable, the lines can be "burned in" by mowing in the same place and direction each time. Additionally, edging greatly improves the look of the lawn and landscape. Clean lines that sharply mark the contrast between grass and other plants or hardscapes are pleasant to see.

Although good color is the most appealing, even brown grass can be attractive if it is consistent. If the lawn is mostly dormant, then it is important to remove or spray spotty areas of green grass or weeds. It takes only a few invasive plants to spoil the appearance. Look at other lawns and landscapes to see what is the most impressive. Familiarity with your own site keeps you from noticing the details. Try to see the landscape through the eyes of the Park patrons and it will give you the basis for improvement.

Fertilization

Apply fertilizer based on soil analysis recommendations that outline a turf fertility program for a one-year period. This helps to avoid unnecessary applications and applying the wrong nutrients for turf needs. Apply organic based and slow release fertilizers. Fast release formulations produce fast top growth on turf but do not promote strong root development. They also reduce natural microbiotic activity in the soil and leach out of the soil easily. This rapid turf growth requires more water and more frequent mowing to manage. Avoid moderate or heavy fertilizer applications during spring and summer as this stimulates topgrowth and leads to higher water use.

Monitor potassium levels during periods of high temperatures and drought. Increased potassium nutrition has been reported to increase

rooting depth and mass. This increased rooting capacity contributes to improved drought resistance and recovery.

Once the weather is cold most turf managers will try to maintain at least some growth with soluble, quick-release fertilizers. Nitrates are usually considered the best bet when both the ambient and soil temperatures are low. Check the fertilizer analysis to make certain that at least half the nitrogen in the material is in the nitrate form. The general philosophy is that the other primary nutrients, phosphorous and potassium, are poorly utilized in cold weather. Certainly, there are exceptions, such as when nitrate is combined with potassium to form potassium nitrate. Ask your supplier about other highly soluble combinations.

When the weather is very cold turf growth will likely be negligible, no matter how much fertility is applied. Turf managers are usually satisfied at these times if they can maintain a reasonable degree of turf color. Applications of iron, usually in liquid form, can restore good color to grass that has a bleached out look from frosty nights.

Edging

Turf shall be edged along sidewalks, curbs, and shrub or ground cover borders at least every two weeks during the active growing season and as needed for appearance the remainder of the year. Edging should be performed with a blade type mechanical edger. The cut edge should appear as a clean, smooth line. Keep sprinklers from being blocked from turf. Sprinklers in turf should only be edged to allow for proper distribution of water. Also, turf shall be kept away from all tree trunks. String trimmers are not to be used around trees, as they damage trunks.

Aerification

Periodic aerification of turf areas is one of the most important cultural practices that we perform. All soils can benefit, not just those that drain poorly or are subject to high traffic. The rewards are numerous. Overall

maintenance costs can be lowered, turf quality can be improved, and nuisance problems can be reduced. Although there are some temporary disadvantages associated with aerifying, they are far outweighed by the advantages.

A “normal” soil will be composed of about twenty-five percent air. Over time, this pore space begins to be reduced by compaction from foot traffic, vehicles use, and maintenance equipment. This loss of pore space begins to create a number of problems. Unfortunately, the usually gradual increase in compaction can cause the turf manager to miss its detrimental impact on the turf. For this reason, aerifying is often one of the cultural practices that is eliminated when there are time or budget constraints.

Mechanical aerifying breaks down broadly into two categories, solid tine and core removal. The latter method, core removal with a hollow-tine unit, is the focus of this article. It is generally thought to last longer and offer more advantages. There is a machine available for almost any site or turf type. Usually, finely maintained turf requires a close pattern of tines with tine diameters of no more than 5/8 inches that penetrate the soil four inches or less. Larger, or low use, turf areas may use a tine size up to one inch in diameter that is on a wider spacing and penetrates several inches into the soil.

Aerification reduces the bulk density of the soil and helps to restore pore space. Roots need these voids in the soil structure in order to have a place to grow. On smaller, intensive use areas, aerifying offers an opportunity to amend the soil profile by filling the holes with a superior material. On large areas this may prove to be impractical. But leaving the holes open can also have its advantages. Water penetration will likely be dramatically improved on dry or hydrophobic soils. Conversely, drying of persistently wet soils will be accelerated. Shattering the removed plugs with a drag can act as a light top dressing, helping to control the thatch accumulation in a mature stand of turf.

The improved water penetration means less runoff, which equates to lower run times and less water usage. This also means that fertilizer applications will be more effectively introduced into the soil profile and the increased oxygen in the soil system will improve the reactive time of the fertilizers. Another advantage to aerifying that is seldom mentioned is that toxic gases in the root zone, a by-product of plant growth, will dissipate back into the atmosphere.

The disadvantages need to be addressed so they can be managed properly. Essentially they are all short term problems when handled correctly and they carry little weight in an argument against aerification. The first is the temporary disruption of the turf's surface. This can be partially alleviated by good cleanup of the area and prior notification of the work to be done. Secondly, do not schedule aerification unless the desired turf cover is in its growth season. For example, aerifying non-overseeded dormant bermudagrass will likely cause an infestation of undesirable weeds.

Another important item to be aware of is the potential for rapid desiccation or drying out of the turf and soil. This is usually easily countered by an immediate irrigation. Also, make certain that the soil has good moisture when the project begins and avoid aerifying in the heat of the day. Lastly, be prepared to treat for insects thatch inhabiting insects, such as cutworms and sod webworms, that will take up residence in the aerification holes. All of these concerns can be satisfactorily addressed as long as there is an awareness of the risks involved.

How often should a given turf area be aerified? Since not all compaction is alleviated in a single aerification, it is hard to overdo it. Aerification shall be performed in turf areas a minimum of 3 times per year to promote deep rooting, improve water penetration, and reduce soil compaction. Aerate as deeply as possible, 2 to 4 inches. This is especially important in Capitol Park due to the high intensity of foot traffic and many events held on the grounds.

Turf shall be aerated when roots are most actively growing. The first aeration can take place in early spring when roots are starting up growth as the soil temperature warms. The next aeration can take place in late spring or early summer when roots are still expanding. Cool season grasses slow or stop root growth in the hot summer months, so it has little impact. The third aeration can occur in late September or early October to coincide with cool season turf root activity. Warm season grasses may need only a single aeration, depending on their use, since they have a shorter growing season and more vigorous growth.

*Incorporate organic materials into turf soils. Organic materials can include a fine composted top dressing applied after aerating.

Turfgrass Pest and Disease Control

If turf is maintained in a healthy and vigorous growing condition, it is less susceptible to pests and diseases, and the problems are less severe then when in poor health. Refer to the procedures on Integrated Pest Management for additional information. If any pest or disease problem is detected, it shall be reported to the grounds supervisor to determine the action.

Turfgrass Wear Management

The collective damage on turfgrass from traffic of all kinds is commonly referred to as *wear*. Traffic on turf can be either vehicular or foot traffic. And while traffic can cause other problems, such as soil displacement or compaction, the focus here is on the wear issues. Turfgrass managers spend a great deal of time avoiding wear by diverting the traffic in some manner, resisting the effects of wear through species selection and sound cultural practices, and recovering from at least some wear damage.

Whenever possible, traffic avoidance is the prudent course. This may be possible in certain situations, but generally it is not in the Park. Look for methods of traffic control, as opposed to traffic avoidance. The placement of hedges, trees, walks, cartpaths, contours, and other features

can all be either a help or a hindrance in regards to traffic control. These permanent features often protect one area of the turf at the expense of another.

Changing foot traffic patterns frequently to avoid concentrated wear can work fairly well on large turf areas. An excess of unsightly ropes and signs should not be used for traffic control. As people will take the most convenient route, it will take only a small obstruction to move them in a different direction.

When a turf area is designed for extensive use, a wear resistant species of grass should be planted if at all possible. Trying to maintain a poorly adapted species is both frustrating and expensive. When making the decision as to which grass, there are some general rules that apply. The warm season turfgrasses are more wear tolerant than the cool season turfgrasses. The leaves and stems of warm season grasses are usually stiffer and coarser, therefore more resistant to traffic and wear. Grasses planted in shade areas, usually cool season varieties, do not fare well under heavy traffic.

Following proper species selection, good cultural practices offer the best protection against wear. Irrigation management can make a big difference. If a turf is under drought stress the leaves will break easily from traffic, causing an excessive amount of wear. An overly wet turf will also wear easily, with the added problems of soil displacement and compaction. Improper irrigation will also lead to poor turf rooting and adaptabily, further complicating wear issues.

High fertility can overstimulate the turf, making it soft, succulent and susceptible to wear. Inadequate fertility can also leave turf vulnerable to wear. A well balanced fertility program that places an emphasis on nitrogen and potassium will be helpful with wear problems. Fertilize frequently in moderate amounts to avoid the extreme peaks and valleys in plant growth.

Mowing height can be instrumental in the battle against wear. Traffic tolerance is usually increased when the grass is cut a little higher. There is more grass to absorb the shock and the crown of the plant is better protected. Since grasses are often cut below their optimum growing height, raising the mowers can improve the turf's vigor. Higher mowing can also mean that less irrigation and fertilizer are required and the added leaf area means it will have a greener appearance.

Regardless of how well we resist wear damage, it is inevitable that some wear will occur. Recovery from wear again means sound cultural practices. In addition to the cultural practices mentioned earlier that can promote healthy turf, aerifying and topdressing will relieve compaction and provide space for new roots or seedings to establish. Worst case of course, managing wear areas means re-establishing the turf with sod, seed, or stolons. But hopefully wear will not reach that point. However, recovery may mean continually seeding into an existing turf stand. Sometimes turf managers will broadcast seed over healthy turf in anticipation of heavy foot traffic, such as preparing for large galleries at golf tournaments.

Proper species selection in critical for recovery as well as for resistance. Certain grasses have a much greater recuperative value than others. Keep in mind, however, that grasses with a high degree of resistance to wear may not be the first to recover.

Establishing Lawns

When preparing for a new lawn, there are three methods from which to choose for establishing the turf. The choices are sod, seed, or stolons. Methods such as "plugging" or "sprigging" are impractical in high profile settings like Capitol Park. The latter term, *stolons,* refers to freshly cut stems that are incorporated into the soil. Stolons will establish roots from the nodes on the stems and eventually regrow into full scale grass plants. This method is mostly used for turf varieties that do not produce a viable seed. These turf varieties are hybrids, a cross

between two different turf types where the resulting offspring is sterile. It is the most difficult to get right of the three methods and is not generally recommended for highly managed turf areas.

Measuring for New Turf

Most often turf managers will multiply the length by the width to arrive to arrive at the total number of square feet for the area. If the area is square or rectangular, this method is great. But what if it is not? What if it is circular, or triangular, or has ends of uneven length? If you know the formulas for finding the area of these shapes, a simple and accurate determination of how much sod should be ordered can quickly be made.

When solving for the area of a circle use the formula Area= Pi(3.14) times the radius squared. Pi is designated by the sixteenth letter of the Greek alphabet and is a constant in a wide range of mathematical problems. The radius of a circle is the measurement taken from the circle center to the outside. It can also be defined as half the diameter. Squaring the radius means multiplying the number times itself. Square the radius first, then multiply the result by 3.14. This final number will be the area inside the circle.

Sites that are uneven, but generally circular, can be accurately measured by averaging several evenly spaced tape measure readings from an approximate center and using that number in the formula. In this system, a compass is placed at the approximate center of the lawn area and readings are taken every 10 degrees, for a total of 36 measurements . These are averaged for a final number that is used in the circle formula.

Driveways, buildings, landscape beds, and other encroachments sometimes dictate that a turf area be in a triangular shape. If the sides of the triangle are fairly even, the square footage of the area can be determined by multiplying the base times the height and dividing the result by two. The height is determined by measuring from the centerpoint of the base to the tip of the triangle. Of course, the area

square footage could still be found even if the sides were of radically different lengths, but the math gets more complicated.

Another common shape that is frequently difficult to accurately measure is the trapezoid. This term is defined as a four-sided figure with two sides parallel. Essentially it is a rectangle with uneven ends. This is an extremely common lawn configuration because the home and sidewalk form the parallel length boundaries of the trapeziod, with landscaping or other features causing the ends to be uneven. The square footage of these areas can be found by by adding the two lengths, dividing this sum by two, and multiplying the result by distance between the two parallel sides. It is easy to make these formulas sound more complicated than they really are. As with the circle, all you are doing here is averaging back to a uniform shape - in this case to the rectangular shape.

While measuring for sod or seed quantities are only two of the many instances in which turf managers use math, it does show that the process can be fairly simple. With continued study and practice, a comfort level can soon be developed. Practice in one area of calculations until you are confident in the results, then move on to another area. the benefits will be worth the effort.

Turf Establishment by Sod

Although sodding is the most expensive method of developing a new lawn, it offers several advantages over using seed or stolons. The most obvious advantage, of course, is the immediate appearance of a mature and beautiful lawn. Another advantage is a great reduction in the risk of poor establishment of the turf from seed or stolons. Additionally, there is much to be said for getting the jump on weed seeds in the soil that can quickly establish themselves. Multiple irrigation cycles, potential wash-outs and extra fertilizers applications are other time consuming details involved in growing in a new lawn that turf managers would sooner avoid.

Keep in mind, however, that while new sod looks mature, it needs time to establish. Automobiles, riding lawn mowers and any other heavy equipment can do extensive damage to newly sodded areas. The same goes for heavy foot traffic that can shift the sod or cause excessive wear. Depending on the time of year, several weeks can be required before sodded lawns are full use areas. And while new sod does not need as much irrigation as seed or stolons, the moisture content should be monitored carefully to avoid drying out. In fact, inadequate irrigation constitutes the greatest risk to newly laid sod.

Whether a site is being prepared for seeding, stolonizing, or sodding, the process is essentially the same. A soil bed prepared for sod should be as smooth and firm and as well amended as one prepared for seed. Fertility requirements at the time of planting or sodding will also be similar for all three methods. A fertilizer relatively high in phosphorous and low in nitrogen should be applied to the soil before either sodding or seeding. Remember that adding fertilizer before planting represents your last good opportunity to blend nutrients directly into the root zone. Although not imperative, unless there is a history of soil problems, testing the soil before final preparation for specific nutrient defiencies is always a good idea. Since sod prices and quality can vary among growers, it is best to do some research before you buy.

There are procedures for laying sod that will aid in the successful establish of the the turf, and in some cases, improve the appearance of the final product as well. First, the soil should be moist but not overly wet. Irrigating the site thoroughly the day or night before, thereby giving the soil a chance to drain, is a good idea. A thorough watering will also expose any low spots or drainage problems you may have. Once a section of sod is laid, the area should again be irrigated until water has moved through the sod into the soil. In the short term, more water is better than less.

To help with the stability of the sod as well as the underlying soil, sod lengths should be laid perpendicular to the movement of water across the site. In cases where the installation is on a particularly steep slope, or

where drain water will move rapidly across the sod, it is advisable to stake the sections to the soil until the turf is well established. It is also important that the ends of the sod lengths do not match up with those in the previous row. An alternating pattern is best, similar to what we see in a block or brick wall. The sod lengths should fit tightly and firmly against the adjacent sections. On smaller sites where smoothness is critical, hand tamping as you go may be necessary. Ideally on larger areas, a mechanized roller is driven over the area in one or two directions after sodding to ensure smoothness and good contact with the soil. If you contract the work, ask them to roll the sod after the installation.

The more closely mowed the sod is at delivery, the more obvious will be the seams between the sections. For example, hybrid bermuda mowed at one half inch will have seams that are much more apparent than ryegrasss or fescue sod mowed at one inch. To improve the initial appearance of newly laid sod, and to minimize the amount of patching of odd sized areas at the end of the job, match the first course against a stringline across the lawn. Sometimes a property line, wall, or sidewalk will give you a straight marker from which to begin.

Sod can be either laid mechanically or by hand. Sod rolls that are machine laid are longer and wider, and therefore more stable. This type of contract installation is usually reasonly priced and quick to install. However, for mechanical sod installation jobs to be practical, the area must allow good access and be of several thousand square feet in size. If the sod is hand laid, care should be taken that neither the sod sections already installed nor the soil bed is disturbed by the workers. Plywood sheets or wide boards can be used to protect the area from damage. As a further note of caution, sod should never be delivered to a site before it is ready. The sod may dry out or be damaged from heating inside the rolls. If the sod does have to sit for some time, it should be unrolled and watered.

With good preparation and proper installation, sodding a lawn can be an excellent choice. While it costs more to sod than either seeding or stolonizing, the immediate good impression and reduced aggravation

may well be worth the difference. Actually, you may discover that sod is a surprisingly reasonably priced option. This is especially true in situations where you may need the area soon for an event. Whatever your reasons, sodding is worth considering.

TREE MAINTENANCE

Evaluating the Planting Site

Plant trees in safe locations where they are sure to thrive. The goal is to plant the right tree in the right place. This is the essential philosophy for reduced tree maintenance. Ask yourself, "Will a tree grow well in this spot? Is there enough space for the tree to grow to mature size without hindrance from other plants, sidewalks or structures?"

General Site Conditions

- *Setting* – urban location or open and natural
- *Nature* – native, imported, cut or fill soil
- *Topography* – level, in a swale or on a hillside

Specific Site Conditions

- *Above Ground Space* – Distance from utility lines, light poles, signs, traffic lights, important views, fences, traffic, buildings and other structures.
- *Surface Space* – Distance from curbs, walks, streets, patios, light and irrigation fixtures, etc.
- *Underground Space* – Distance from water, sewer, electrical, and gas lines, basements, storm drains and other structures.
- *Pests*- Are there rodent or other animals that may damage trees?

Soil Conditions

- *Soil* – Understanding the site soil is very important. Good soil is a mass of mineral particles mixed with living and dead organic mater and incorporating quantities of air and water. Healthy tree growth is dependent on having fertile soil that is free from contaminants.

- *Soil Texture/Structure* – Is the size of the individual mineral particles. In order of their fineness, soil is classified as clay, silt, fine sand, medium sand, and large sand. What is the soil structure with respect to compaction, permeability, composition, drainage, and aeration?
- *Soil Amendments* – the material that can add both air and water-retention to the soil. Organic amendments are ground bark, leaf mold, peat moss, sawdust, manure and others. They decompose yielding an end product called humus. Humus is a soft material that binds together minute clay particles into large "crumbs" improving aeration and drainage. To improve poor soils mix a volume of organic amendments equal to 25% of the total soil volume. Adequate soil nitrogen is necessary to decompose the amendments.

- *Soil Testing* – It is important to test soil in unfamiliar planting areas before major tree plantings. If time permits, plant small plants to determine how well they will grow in new site soils. For more accurate information, a professional soil test is helpful to determine what kind of soil amendments and fertilizer may be required.

- Climate and other Site Conditions

- *Temperature* – What are the temperature ranges?
- *Reflective heat and sunlight* – Are there structures or other surfaces that may reflect intensive heat or light on the tree?
- *Humidity* – Is the humidity levels excessive?
- *Sun exposure* – How much sun and shade will the tree be exposed to?
- *Wind* – How much heavy winds will the tree be exposed to?

- *Rainfall* – How much rain or storm water will the tree be exposed to?
- *Air pollution* – Will the tree be exposed to heavy vehicle exhaust or other pollutants?

Tree Selection

Selecting a Quality Tree

After you have identified which species will work for your planting site, you will want to select quality plant material. You should look at several things:

- *Roots*-select trees that have good roots and are not rootbound

- *Trunk*-the tree's trunk should be straight, strong and free from wounds.

- *Branches*-a tree's branches should be well spaced vertically and horizontally along the trunk so they will not interfere with each other as they grow.

- *Leaves*-leaves should be healthy and free from damaging pests.

After the planting site has been evaluated one must identify the right tree species and then select a quality tree. You want to select trees that will be manageable in the right place. If it is not going to be managed, it should not be planted because the problems it may cause will outweigh the benefits it can provide. A typical plant selection guide will consider all of the species characteristics:

- *Size*-How tall and wide will the tree grow?
- *Shape*-What shape will the tree have when mature?
- *Growth rate*-how fast will the tree grow?
- *Roots*-will roots have room to grow without damaging the site?
- *Leaves*-size, color and litter cleanup.
- *Flowers and fruit*- Size, color, insect attraction and litter cleanup.

- *Wildlife*-does the tree attract good or bad wildlife?
- *Hardiness*- can the tree take heat and cold conditions?
- *Durability*-can the tree thrive in adverse site conditions with heavy winds?
- *Exposure*-does the tree require full sun, half-sun or shade?
- *Soil conditions*-what kind of soil can the tree thrive in? Is it sensitive to salt or a high pH?
- *Water requirements*-can the tree live on rainfall or will it need additional water?
- *Utility lines*-can the tree grow under utility lines without having to be pruned?
- *Maintenance*-how much pruning will it require?

Trees should receive deep watering to encourage a deep root system and discourage surface rooting. Water should penetrate at least 24-36 inches into the profile. Soil moisture levels and watering depth shall be checked weekly with a soil probe to ascertain the subsoil conditions. If a saturated condition is found, it is an indication of drainage problems or excessive irrigation applications and shall be reported to the grounds supervisor. Irrigation schedules should be based on current climate conditions from CIMIS data and the water needs of the tree species.

Tree Fertilization

Apply fertilizer based on soil analysis recommendations that outline a fertility program for a one-year period. Tree fertilization shall be based on the specific needs or possible nutrient deficiencies as determined by a soil analysis.
Use slow release, organic based fertilizers to avoid rapid growth that will require more labor for pruning and green waste disposal.

Most mature trees do not need supplemental fertilizer, and trees located in turf areas most probably receive what they need from applications for turf. These trees do not require additional fertilization unless nutritional deficiencies are observed. Any signs of leaf chlorosis, leaf tip burn, or

any other signs of poor health and growth should be brought to the attention of the grounds supervisor.

Tree Pruning

Tree pruning has three basis objectives. These are to promote structural strength and balance, to accentuate the trees natural form and features, and to protect public health and safety. The following are general pruning guidelines:

Tree species vary in growth rate and habit, and pruning activities should be developed to achieve the best results. This is important due to the eventual size and impact trees have within landscapes. The following guidelines promote structural integrity and healthy trees and are based on International Society of Arboriculture (ISA) standards.

It is best to prune trees when they are under the least amount of stress by environmental factors such as extreme heat or drought. This means that most deciduous trees should be pruned principally when they are dormant, typically during late fall and winter. Evergreen trees should not be pruned just before their main growing season in early spring, or in late fall so that the late season growth is damaged by frost. Conifers are not typically pruned routinely, but rather on an as needed basis. They may be pruned to enhance or redirect the shape of the tree or to remove a limb that has become an obstacle.

When trees are pruned correctly at a young age, they typically require fewer and less drastic cuts as they mature. Young trees should be pruned to promote the basic canopy framework upon which trees will be built as they mature. Careful pruning of trees when they are young can eliminate the need for drastic pruning later on.

Prune young trees to develop strength and form. Remove lateral branches that are: greater than ¾ the size of the central leader, the smallest of two branches creating narrow v-shaped branch forks, water sprouts and suckers, diseased, damaged, rubbing branches, weakest and

smallest branches to establish a vertical spacing of 8 to 12 inches between branches, and the weakest and smallest branches to establish an even radial distribution around the trunk.

Do not remove lower branches on young trees at the time of planting. Retain as much foliage on these branches as possible. Remove lower branches only when the tree is able to stand erect without staking or other support.

Generally, a maximum of 15% of the total tree foliage should be removed at any one pruning operation. Exceptions to this rule include: tree canopies thinned to prevent wind from blowing trees over prior to winds, following a severe root pruning, or tree canopies with brittle branches that are too top heavy. Removing too much of the tree canopy can affect the ability of the tree to supply itself with food during the photosynthesis process. Therefore, removing too much foliage is equivalent to starving the tree. Another problem with overpruning is that trees are susceptible to sunburn. A sudden defoliation will expose the tree to the hot, scalding sun. Sunburned trees become wounded more easily and are more susceptible to disease and decay.

A properly pruned tree seldom looks pruned. If it appears obvious that a tree has just been pruned, then it has probably been pruned incorrectly. All trees do not need pruning and many will probably develop adequately without any pruning. However, pruning can reduce and eliminate any imperfections that may develop. Removing branches over one-inch in diameter or larger can be necessary for reasons that include: eliminating diseased, dead, or broken branches; branches that obstruct structures or utilities; block adequate clearance at walkways or driveways; heavy branches in high wind areas; and branches that detract from the desired appearance of the tree.

Trees should never be topped. Although this practice was once common, it is now recognized as detrimental to tree health. Topping drastically alters the natural structure of the tree, promotes weak new growth, and changes forever its natural form. In some instances, the tree must be cut

down and replaced. Topping trees encourages vigorous sprouting and increases the frequency of pruning cycles, resulting in increased maintenance costs.

Reducing the tree crown may be desirable and necessary sometimes. This can be accomplished by crown reduction. This involves the removal of selected smaller branches back to the main branch. Cuts are made only on small branches close to the main branch or trunk, leaving a collar of the branch left rather than a stub. These new cuts normally heal rapidly and completely. This practice of proper thinning reduces the height and spread of the tree, yet retains the tree's natural shape.

Pruning cuts should occur in branch tissue just outside the branch bark ridge and collar. Heading cuts or stubbing is not permitted. All pruning for both young and mature shall be made in accordance with the International Society of Arboriculture (ISA) pruning standards.

Mechanical Damage to Trees

The tree health problems that stem from our maintenance practices include mechanical damage from grass mowing, excessive and improper pruning, and daily overwatering. The biggest culprit from mechanical damage is from the string trimmers that are used to trim around trees. Most turf and landscape managers have witnessed the loss of small trees from this type damage, but even large and well-established trees will succumb eventually. Trees damaged from string trimmers will assuredly either die or remain stunted for life.

String trimmer damage begins when the high-speed string cuts the protective bark layer. This covering is the tree's equivalent of skin. Just beneath the bark lies a tissue called the *phloem.* Its role in growth and health is to transport food, in the form of sugars, from the leaves to the roots and others parts of the tree. These tissues are so close to the surface they are sometimes called the inner bark. If damage continues, it will occur next be to the *cambium* layer. These cells are located between

the *phloem* and the *xylem* layers. The function of the cambium is the production of new cells for phloem and xylem tissues. If this layer is severely damaged, the diameter of the tree will cease to expand and the life of the tree will be endangered.

Why do we continue this maintenance practice when the risks to our trees is so great? One reason is the "death by degrees" scenario, where years are taken for the damage to be noticeable. In other cases trees are just not given a very high priority. Accountability is low, since it is seldom evident that the maintenance practices being used have killed, or severely damaged, the trees.

If string trimmers must be used, there are ways of protecting the trees. On small or newly planted trees a sleeve can be placed around to lower trunk. Better still, for all trees, a "turf free" circle can be created at the base and covered with mulch to eliminate the need for close mowing. Using a piece of rope and the tree for a center point, perfect circles can be drawn for turf removal. The finished look is very appealing and leaves an impression that the area is well maintained. As an added benefit, you will have created a better environment for the tree roots.

Excessive or improper trimming is a huge detriment to trees. One of the worst of these trimming practices is tree "topping". When trees are topped their natural beauty and growth habit is destroyed. Even with regrowth, the character and grace of the tree is seldom restored. New limbs that sprout on topped trees are usually weakly attached and topping can shock a tree to the point of death. At best, the large cuts and shock effects will leave the tree vulnerable to insects and diseases. Good pruning conforms to the natural shape of the tree and reduces the crown by less than one third.

The last faulty maintenance practice mentioned here, overwatering, usually occurs because the irrigation schedule is set for grass. However, it is all too common that the grass is also overwatered. Adjustments can generally be made in the irrigation schedule that accommodates both

lawn turf and trees. Trees are a great enhancement to any landscape and well worth the trouble of proper maintenance.

Tree Pests and Disease Control

If all trees are maintained in a healthy and vigorous growing condition, they are less susceptible to pests and diseases, and the problems are less severe than trees in poor health. If any pest or disease problem is detected, it shall be reported to the grounds supervisor to determine the action.

Tree Failure Formula

A determination of each tree's potential to fall or "fail" is based on the t/R>0.30 formula as described in The body language of trees – a handbook for failure analysis by Claus Matthech and Helge Breloer. The t/R value can be defined as the depth of sound wood divided by the radius of the tree trunk. For example, if a tree has three inches of sound wood on the perimeter with interior decay, the three inches is divided by the tree's radius. If the tree is 24 inches in diameter, then the radius is 12 inches. Dividing 12 inches into 3 inches results in t/R = 0.25. In this particular example, the tree would not meet the standard of t/R>0.30. Trees that do not meet the t/R>0.30 value on more than one third of the tree's perimeter are also deemed to have high failure potential.

Tree Protection

Staking and Guying

The purpose of staking and guying trees is to support and protect young trees until trunk development occurs to such a time that the tree can stand properly without support. Trees shall be inspected on a regular basis to prevent girdling of trunks or branches and to prevent rubbing, which results in bark wounding. Groundskeepers shall be responsible for the adjustments necessary to the tree ties to prevent girdling and wounding.

Inspections shall also include stake stability and evaluating if the tree needs to be staked any longer.

All groundskeepers shall maintain in proper working order all stakes and guys. Replace any broken stakes, ties, or guying assembly components if needed. Reposition or replace any tree stake that is not firmly embedded in the soil, so that it may properly anchor the tree. Adjust all ties that are scarring or girdling the trunk. Adjust all guy wires to retain a taut position. Maintain all PVC guy wire pipe, and drive all wire anchor stakes 2 inches below finish grade for public safety.

Stakes and guys shall be removed when it is determined by the Certified Arborist that they are no longer required. Each tree species will have a different degree of establishment period and should be evaluated for appropriate caliper and strength prior to the removal of ties and stakes. Remove stakes and guy wires only when the tree has proven to be structurally stable. Trees must be capable of retaining an upright position under variable soil and wind conditions. Seasonally, the best time for removal is early to mid-spring after the rainy and seasonal wind periods. If the tree is still unable to support the weight of its canopy or it bends inappropriately when pushed firmly, then the tree likely will require retying.

Tree Trunk Protection

A bare soil tree buffer zone of 6 inches shall be maintained around all trees. This is a circle with a radius of 6 inches beyond the bark line of the tree, which shall be maintained free of turf, ground covers, and weeds.

Within this 6 inch zone, only hand or chemical methods of control (no string or blade trimmers) may be used for clearing. Outside this zone clearing may be done with string or blade trimmers, shovels, or herbicide, with extreme caution to not damage tree trunks.

In areas where the turfgrass meets the tree directly and no buffer zone exists or no trunk guard is in place, edging shall be done with hand shears only.

Tree Protection during Construction

A protective fence a minimum of 4-foot high should be erected around all trees in a construction zone. The protective fence should be installed ten feet beyond the dripline of each tree. This will delineate the tree protection area and prevent unwanted activity in and around the trees in order to reduce soil compaction in the root zones of the trees and other damage from heavy equipment. Fencing shall be removed only after all construction activities are complete.

Avoid heavy equipment operation around the trees. Operating heavy machinery around the root zones of trees will increase soil compaction, which decreases soil aeration and subsequently reduces water penetration in the soil. All heavy equipment and vehicles should, at minimum, stay out of the fenced tree protection zone, unless where specifically approved in writing and under the supervision of a Certified Arborist.

Do not discard any supply or material, including paint, lumber, concrete overflow, etc. within the protection zone. Avoid draining or leakage of equipment fluids near retained trees. Fluids such as: gasoline, diesel, oils, hydraulics, brake and transmission fluids, paint, paint thinners, and glycol (anti-freeze) should be disposed of properly. Keep equipment parked at least 50 feet away from retained trees to avoid the possibility of leakage of equipment fluids into the soil. The effect of toxic equipment fluids on the retained trees could lead to decline and death.

Grade changes, including adding fill, should not be permitted within the tree protection zone, without special written authorization and under supervision by a Certified Arborist. Lowering the grade within this area will necessitate cutting main support and feeder roots, jeopardizing the health and structural integrity of the trees. Adding soil, even temporarily, on top of the existing grade will compact the soil further,

and decrease both water and air availability to the trees' roots.

Care will be taken when moving equipment or supplies near the trees, especially overhead. Avoid damaging the trees when transporting or moving construction materials and working around the tree (even outside of the fenced tree protection zone). Above ground tree parts that could be damaged (e.g., low limbs, trunks) should be flagged with red ribbon. If contact with the tree crown is unavoidable, prune the conflicting branch(es) using ISA standards.

All trenching should be outside of the fenced protection zone. Roots primarily extend in a horizontal direction forming a support base to the tree similar to the base of a wineglass. Where trenching is necessary in areas that contain tree roots, all cuts should be clean and sharp, to minimize ripping, tearing, and fracturing of the root system. The trench should be made no deeper than necessary.

Trees that have been substantially root pruned (30% or more of their root zone) will require irrigation for the first twelve months. The first irrigation should be within 48 hours of root pruning. They should be deep watered every two to four weeks during the summer and once a month during the winter (adjust accordingly with rainfall). One irrigation cycle should thoroughly soak the root zones of the trees to a depth of 3 feet.
The soil should dry out between watering; avoid keeping a consistently wet soil.

Check soil moisture with a soil probe before irrigating. Irrigation is best accomplished by installing a temporary above ground micro-spray system that will distribute water slowly (to avoid runoff) and evenly throughout the fenced protection zone but never soaking the area located within 6- feet of the tree trunk, especially during warmer months.

Do not prune any of the trees until all construction is completed. This will help protect the tree canopies from damage. All pruning shall be completed under the direction of an ISA Certified Arborist and using

ISA guidelines. Only dead wood shall be removed from tree canopies.

Periodic washing of the foliage is recommended during construction but no more than once every two weeks. Washing should include the upper and lower leaf surfaces and the tree bark. This should continue beyond the construction period at a less frequent rate with a high-powered hose only in the early morning hours. Washing will help control dirt/dust buildup that can lead to mite and insect infestations.

Tree Removal

As with all mature landscapes, trees will eventually require removal and replacement - and in some circumstances removal without replacement. It is important to identify and report trees in the landscape with the following circumstances: poor performance due to tree health problems or have already resulted in death; excessive maintenance required due to their particular condition; potential personal or property damage to buildings, hardscape features, or utilities; the cost to retain the tree exceeds the benefit it provides; or any tree which represents a hazard to public use of the park. Any of these observations should be reported. The Landscape Architect and Certified Arborist on staff shall be consulted to make the final tree removal recommendation.

Overcrowding in maturing landscapes can occur when plant materials grow to where they extend into buildings, pedestrian or vehicular circulation paths, or into adjacent plantings. Removal becomes necessary when the plant health and vigor, aesthetics, and/or public safety are threatened. During regular landscape inspections, possible overcrowding should be noted, and removal should be determined by the Landscape Architect or Certified Arborist.

The following are requirements for any removal:

- All trees removals shall be performed in a safe and professional manner without damage to any other surrounding improvements. Any drainage items, irrigation equipment, or hardscape elements that

were damaged during the removal process shall be repaired or replaced.

- All tree removals shall include removing and grinding the stump down into small chips to a minimum of 18 inches below finish grade.

- Wood chips created from the stump grinding process are to be removed, and the void left is to be backfilled with soil. Soil placed in the void shall be compacted and fine graded suitable for seeding or planting.

- All green waste generated from the removal process including trunk, branches, leaves, and roots should be removed from site and taken to the North B facility.

- Removal of trees shall include stump removal (under 3 inches diameter) and stump grinding (over 3 inches diameter) to 18 inches below grade. Wood chips shall be removed and the site backfilled with native soil and compacted to grade. All wood or leaf waste material shall be reduced, reused, or recycled.

Tree Replacement

Selecting the right tree species in the right place will avoid many problems and expense in the future. The tree should be able to mature to its fullest potential in its location without impacting surrounding hardscape or buildings. Final tree selection and placement shall be determined by the landscape architect.

If a tree is being replaced, careful analysis shall be made of the site or maintenance conditions which caused or contributed to the tree's decline in health or death.

When replacing trees, typically a 15 gallon size is the smallest recommended size. Follow the tree planting procedures and details for proper methods.

Tree Planting Procedures

- Planting holes shall have irregular, nonglazed sides, and shall be a minimum of twice the diameter and one to one-half times the depth of the original plant container.

- The tree or shrub shall be placed in the planting hole such that the top of the root ball is one inch above the finished grade and soil is sloped away from the root ball to finished grade.

- Backfill shall be composed of on-site amended soil as prescribed by the approved soil report.

- Staking should be the minimum necessary to ensure the tree is protected from high winds or vandalism. The minimum is one stake per 5 gallon tree and two stakes per 15 gallon or larger tree; 36 inch box trees shall be guyed. See the staking and guying details provided in the guidelines book.

- Create a ring of soil at two to four inches above the finished grade surrounding the root ball to collect water.

- Two inches of approved mulch shall be applied to cover the root ball areas. However, do not put mulch within six inches of the tree or shrub trunk.

Transplanting procedures

The cutting of roots should be done a cleanly as possible when the tree is extracted. Pre-watering for good moisture levels when harvesting is very

important. In fact, good moisture in the root soil is very important throughout the transplanting process. Trees that are dug for transplanting should be either bound in strong cloth (burlap or other) or boxed. For trees that have a two inch diameter trunk at a six inch height, the root ball should be approximately 24 inches in diameter. For a three inch diameter trunk, the root ball size should be about 32 inches. When a transplanted tree trunk diameter exceeds six inches, the root ball diameter size should be 10 inches for each inch of tree trunk diameter. For root balls that are 20 inches or less in diameter, the appropriate depth of the root ball is around 75 percent of the width. As the width increases, depth of the root ball can be somewhat reduced – to approximately two thirds of the width.

The planting hole should be approximately twice the diameter of the root ball. Unless the soil is extremely poor, no amendments need be added. If amendments are truly necessary, the hole should be larger than two times the root ball to allow for maximum root growth. Unfortunately, tree roots will not aggressively move from amended soil to the surrounding native soil. Fully composted amendments are preferred, but other high quality organic amendments can be used as well. However, be advised that non-composted organic materials can extract fertility from the soil during the decomposition process.

Trees should be planted slightly higher than soil grade (two inches of root ball above soil level). Soil moisture should be monitored frequently for at least a year, and periodically thereafter. If necessary, newly transplanted trees can be supported with opposite stakes that run a cord to the tree trunk. There should be a minimum of two feet of clearance between the tree trunk and the stakes. Where the cords attach to the tree, they should be enclosed in rubber or other protective material. In order to allow some flexibility for trunk movement and strengthening, the cords should be attached to the tree just below the tree's natural bend.

Inspections

All trees should be inspected monthly by a certified arborist. The arborist shall record all safety issues, disturbances, trunk, root crown and branch problems, other hazards, broken branches, injury, stake ties, invasive roots, and diseases. The trees shall be managed accordingly at the direction of a certified arborist. Walkways, curbs, street and other hardscape shall be regularly inspected for tree root damages. Trees causing consistent physical damage or nuisance can be suggested for removal. Arborist shall report all such hazards and recommend corrective action.

SHRUBS AND GROUNDCOVERS

Shrub Pruning

The objective of pruning of most shrubs is to help them develop their natural beauty and fulfill their purpose in the landscape. Shrubs do not need to be constantly pruned to create tight shapes, but rather their natural form should be encouraged and allowed to develop. Pruning shall be done on an as needed basis only to maintain the natural plant appearance as much as possible. Shrub species vary in growth rate and habit, and pruning activities should be developed to achieve the best results. The following are general pruning guidelines:

- Shrubs should be allowed to grow into each other so they can form a mass planting, barrier, or screen. Any necessary pruning shall be done with thinning and shaping cuts, which allow plant materials to blend together in shrub masses characteristic of each individual species. Exceptions to this include those shrubs that were planted with a formal hedge intent, which will require formal pruning and shaping to maintain their intended design.

- All shrubs shall be pruned to prevent the obstruction of walkways and driveways and shall be maintained clear from pedestrian and vehicular views, curbs and gutters, signage, and utilities. When pruning shrubs along walkways, shearing shall be avoided. Instead,

shrubs should be cut back in a manner that retains their natural shape and optimizes their natural form. Shrubs shall also be pruned to minimize blockage of irrigation head watering patterns.

- Thinning cuts on laterals and leaders shall be used over heading cuts. Shearing back of shrub stems and branches is not encouraged unless the plant poses a safety hazard. If the height of a shrub needs to be reduced, thin or head back to the bud node on alternative branches intermittently as needed.

- When pruning remove only the following branches in their entirety:

- Remove low downward turning branches.

- Remove crossing branches; remove the weakest of the two branches.

- Remove conflicting side branches, staggering level alternately from one adjacent shrub to another.

- Remove an occasional interior branch to generate new growth and maintain dense shrub habit.

- Shrubs should be pruned when they are dormant or under the least amount of stress created by environmental factors such as extreme heat or drought. Most shrubs thrive best if they are pruned a maximum of once or twice per year. This should occur after their flowering cycle has finished or immediately before their growth cycle starts.

- Shrubs that are too large for the limitations of their planting area shall be evaluated for removal and replacement with sustainable or low maintenance varieties that only require pruning once or twice every year.

- Most perennials often require heavy pruning in late fall or early winter to renew growth. The foliage normally does not require

shaping at anytime. Spent flower stalks, blooms, and dead growth shall be removed as needed to maintain a clean appearance in the landscape.

Ground Cover Pruning and Edging

- Prune ground covers to keep in bounds of desired planter areas, and trim top growth as necessary depending on species to achieve an overall even appearance. Thin out to remove irregular foliage masses that distract from an overall uniform appearance. Periodically cut back or mow running ground covers, only if necessary for a particular species, to renew growth and improve density and attractiveness. The process of cutting back removes foliage and stem build-up to generate new basal growth.

- Ground covers shall be maintained 6 inches away from walks, curbs, buildings, walls, utilities, turf separation features, tree trunks, and shrub and vine trunks on a regularly scheduled basis.

- Ground covers shall not be trimmed vertically at the edges but rather tapered back at a 45 degree angle to give a natural appearance. The actual method of edging shall be based upon the ground cover foliage characteristics and shall not leave a shredded, damaged edge.

- Vining and trailing ground covers that may grow up and wrap around the trunks of trees and shrubs should be trimmed and maintained in a cleared 6-inch area away from the base of trunks. The intent is not to have large patches of bare soil but rather to maintain a small buffer zone around the base of trunks. This zone shall be maintained weed free with a layer of mulch.

- During inspections, areas where the ground cover is not filling in at an adequate rate covering all exposed soil shall be noted. Sparse areas shall be checked for soil moisture, salinity levels, and irrigation coverage to determine growth problems. Bare areas may require hand tilling of soil, addition of amendments and replanting.

Replanting shall be with rooted cuttings to create a uniform appearance and curtail erosion.

- As with all maintenance tasks, after pruning or servicing the shrubs, ground cover, or vines, all thoroughfares should be clean and free of debris, plant material/clippings, and soil.

Vines

- Vines should be pruned twice per year to reduce woody build-up and provide an open branch pattern with 20 to 40% of the wall or fence exposed through the vine, depending on species and design intent. Vines should be pruned to control growth and direction. They should be kept in bounds. All vines shall be kept pinned to fences and walls to maximize hardscape cover and not allowed to grow over windows, doors, gates, or other structural features.

Pest and Disease Control

- If shrubs and ground cover are maintained in a healthy and vigorous growing condition, they are less susceptible to pests and diseases, and the problems are less severe than those in poor health. Refer to the section on Integrated Pest Management for additional information.

- If any pest or disease problem is detected, it shall be reported to the grounds supervisor to determine the action.

IRRIGATION SYSTEM

System Inspection and Maintenance

General System Maintenance Requirements:

- The irrigation system should be maintained for optimum performance. This should include cleaning and adjusting all sprinkler heads and valves for proper coverage.

- Inspections of the irrigation system while in operation should be made weekly during spring and summer months and biweekly during the fall and winter months if the system is running to detect any malfunction.

- All malfunctioning equipment should be repaired or replaced prior to the next scheduled irrigation.

- All replacement heads should be of the same manufacturer, type, and application rate.

Weekly Inspections

Inspections shall be done weekly by each groundskeeper responsible for their designated area. The system performance shall be evaluated during daytime hours to verify all components are functioning correctly. Methods of inspection shall be visual observations of water on surrounding hardscape and buildings, use of a soil probe for rooting and watering depth, and observation of head operation. Some of the most common irrigation problems found in the field that should be repaired immediately upon discovery include:

- Clogged or worn nozzles and deflected spray can result in a distorted spray pattern. Check the disbursement at each nozzle, ensuring that the orifice is not clogged, obstructed, or excessively worn. Replace nozzles that appear worn, as they may alter flow rates, precipitation rates, and coverage. Inspect the sprinkler housing for damage or debris.

- Check the radius of throw. For rotors ensure that the head is rotating completely.

- Damaged equipment and broken and malfunctioning heads (broken risers, cracked heads) should be replaced immediately. When replacing broken or non-functioning heads, make sure the replacement is identical in manufacturer, model, and nozzle size to the original head being replaced. Replacing with non-matched equipment results in different precipitation rates and uneven water application.

- Blocked heads by surrounding plant material.

- Leaks and breaks in pipes.
- Incorrect sprinkler alignment. Insure all heads are maintained perpendicular to finish grade. This step is critical as even a slight deflection can dramatically reduce the uniformity of water distribution.

- Incorrect sprinkler leveling or insufficient pop-up height.

- Check for low head drainage. Install or adjust head check valves as necessary to insure low head drainage does not occur.

- Mixed sprinkler types with different precipitation rates on the same valve.

- Incorrect nozzle selection for spray heads and rotors, causing overspray, poor coverage, and hydraulic problems. With spray heads this can also include mixing nozzles with different trajectories (flat, low-angle, or standard angle).

- Incorrect arc adjustment in rotors and in variable arc nozzles for spray heads. Insure all arc and nozzle adjustments are correct and not throwing on any paved surfaces or structures. All heads shall be adjusted to eliminate all overspray on sidewalks and structures. Check the coverage of full or part-circle heads, ensuring that the sprinkler is adjusted to cover only the portion of the landscape for which it is intended.

- Incorrect and/or inconsistent system operating pressure resulting in poor coverage and improper sprinkler operation. Too high pressure results in misting and poor uniformity while too low pressure can result in doughnuts shapes of poor uniformity and unequal coverage in the turf. Insure all zones are operating at correct pressure for maximum water distribution uniformity. Adjust flow control valves and/or system pressure regulating valves if necessary.

- Correct any malfunctioning valves. Operate every zone to insure all control valves can be activated. Maintain valves free of debris and silt.

Monthly Inspections

More detailed inspections by an irrigation technician shall be done once a month to evaluate system performance. These detailed inspections shall look at:

- Inspect remote control valves:
- Adjust flow control on valves as needed. Check for weeping valves in the valve boxes. Weeping valves may simply need to be flushed or the diaphragm replaced. Check all wire connections. Check that all valves open and close properly both electrically and manually.

- Inspect all gate and ball valves for accessibility, leaking, and proper operation.

- Check pressure settings on all pressure regulating valves.

- Power supply testing.

- Pump maintenance.

- Check system operating pressure. Use a pitot tube to check for nozzle discharge pressure. If several heads in a zone become weak

or inoperative, there may be debris in the valve or there may be a break in the piping.

- Change sprinkler heads, if necessary, so that all heads on a valve are of the same type. This is to match precipitation rates.

- Consider installing rain shut-off devices, moisture and wind sensors for water conservation.

Other System Maintenance

Check backflow preventers:

All backflow prevention devices shall be checked and certified for proper operation by a registered backflow prevention professional once a year or as required by local requirements. A copy of the current certification shall be kept in the grounds maintenance office.

Pumping facilities:
Clean filter on all regulating control valves. Have a yearly service performed on all facility components (pumps, motors, valves, and controls) by a pump specific trained professional.

Monitor Water Management Practices

All grounds maintenance staff are to inspect areas weekly to evaluate the soil moisture conditions and plant material responses to the irrigation schedules. Use a soil probe to evaluate watering and depth. Excessive sprinkler run times can result in water run-off, water waste, and damage to plants and structures. Irrigating too frequently can result in shallow root zones, constant soil saturation conditions, limited availability of oxygen in the soil for root growth, and an increase of pests and diseases.

Inspections Guidelines

- Signs of water run-off in planters and surrounding areas.
- Puddles of water in planters and surrounding areas, including walkways.
- Signs of water damage to landscape structures and buildings (water stains on buildings and walks, erosion of asphalt and walks).
- Signs of water stress to plants (dry spots in turf).
- Signs of plant damage due to excess water.
- Insufficient or excess soil moisture (moss growing on the soil surface).
- Water well beyond the root zone of the plants.
- Adjust watering program in accordance with changing environmental conditions and specific plant water requirements:
- With central control systems, download weather data from CIMIS a minimum of every other day and adjust schedules.
- Adjust watering program to utilize soil water holding capacity. Match water application rates to soil infiltration rates and/or schedule multiple watering cycles to avoid water run-off.
- Water managers are encouraged to experiment with decreasing percentages of evapotranspiration replacement on turfgrass areas, to determine a reduction value suitable for the specific site conditions.

INTEGRATED PEST MANAGEMENT

Pest Management Goals

- Minimize the impact in the Park on desirable plant species and other landscape assets from the incursion or infestation of weeds, insects, diseases, and vertebrate pests.

- Manage pests so as to preserve the Park and adjacent public landscaped areas as a legacy to the current and future citizens of California.

- Select and manage plant materials that will preserve and enhance the Park as an appealing setting for the State Capitol and as a tranquil and beautiful place for those visiting, working, or living near the Park.

- Protect the Park from the encroachment and establish of insects and diseases that could destroy any of the several historic trees that have been planted over the years.

- Avoid contamination of the Park and surrounding areas from the use of commercial pesticides or other pest control materials.

Integrated Pest Management (IPM) Components

Integrated Pest Management is a preventive approach incorporating a number of objectives including the following:

- Development of healthy plants that can withstand pest pressures.

- Effective timing of handling pest problems at the most vulnerable stage.

- Enhancement of populations of natural, beneficial organisms.

- The judicious and effective use of pesticides.

Pest Control Strategies

- *Host resistance* involves the selection of plant material that has a natural immunity or resistance to a particular pest or group of pests. When the Park is replacing or adding trees, shrubs, flowers, groundcovers, or grass, an effort should be made to use species that have a resistance to pests that are documented as problems in the Park.

- *Threshold tolerance levels* are the levels of pest populations at which pest control actions should be taken to prevent pests from causing unacceptable injury or harm to the area or the host plant materials. Determining threshold levels is somewhat subjective and may depend as much on appearance and maintaining aesthetic appeal as the actual damage done be the pest species. However, some infestations at Capitol Park can be measured, with corresponding initiation of control measures. For example, the severity of an infestation of white grubs (larvae of the *Coleoptera* Order) a problem in turf at the Park, can to determined by counting the number of grubs per square foot beneath the sod.

- *Cultural Control* focuses on the utilization of cultural practices that help manage pest problems by enhancing plant health or by making the immediate environment less favorable for pest infestations. Cultural practice guidelines can be found in other sections of this manual and in the "Resource Efficient Guidelines Report" previously compiled for the Park maintenance operation.

- *Mechanical Control* refers to machines or other devices that either disrupt the establishment of a pest or physically removes it. Mechanical control mainly applies to weed infestations and can be as simple as a garden hoe or a lawn mower. Washing aphids or other insects from leaves is also a form of mechanical control.

- *Sanitation* involves the removal of debris or other materials that can serve as a breeding ground or a source of food for pests. It also refers to insuring that maintenance materials and plant materials introduced into the Park maintenance program are free of weed seeds and plant pathogens. For example, organic amendments such as composts and steer manure purchased for Park use should be certified as "weed free". Grass seed that is used for reseeding or the establishment of new lawns should be labeled as free of noxious weeds. Soil brought to the Park should be inspected for contaminants as well.

- *Monitoring* in an IPM context involves the identification and population measurement of pest organisms as a determinant of their risk to the plant materials or the site. Monitoring works in conjunction with threshold tolerance. Infestation levels should be monitored frequently, in some cases on a daily basis. Identification of the specific pests reduces chemical use by eliminating broad spectrum applications of pesticides. Classes should continue to be conducted with Park maintenance personnel to teach pest identification.

- *Biological Control* involves the use of natural enemies of identified pests. These natural enemies include parasites, predators, and pathogens. Biological control is becoming an increasingly viable option. This is an area of continuing research that will be crucial towards achieving the goal of minimizing applications of commercial pesticides.

- *Chemical Control* in an IPM program refers to Environmental Protection Agency registered pesticides that are used to destroy pests, control their activity, or prevent them from causing damage. Chemicals that regulate plant growth, remove foliage, or suppress reproduction are also classified as pesticides. Chemical use always should be considered the last line of defense in the Park's landscape management program.

Pesticide Safety Guidelines

- Read the pesticide label. Do not apply the pesticide to any target pest that is not specifically identified on the label. Do not exceed the dosage listed on the label.

- Wear safety clothing and protective equipment as specified on the label. Be particularly careful during the mixing process when the pesticide is still in concentrate.

- Post warning signs as to exactly what is being treated and the chemical being used. Have a folder available for inspection that contains both the full label and the Material Safety Data Sheet.

- Store chemicals in a locked and posted facility that meets the requirements of the Department of Pesticide Regulations of the State of California.

- Have a designated emergency medical care facility chosen before any application of pesticides. The applicator and supervisor should have immediate access to the name, address and directions to the facility.

- All applications must be made or supervised by a staff person who possesses either a Department of Pesticide Regulation's (DPR) Qualified Applicators License (QAL) or a Qualified Applicators Certificate (QAC). All applications of materials must be recommended by a California licensed Pest Control Advisor. The Advisor must consider all other options before resorting to commercial pesticides.

Pesticide Application Procedures

- As noted in the Pesticide Safety Section, follow the label instructions for all applications of materials.

- Calibrate the equipment before each use. If using a liquid pesticide solution, determine the amount of solution volume required by using water first. Mix the solution immediately prior to using – do not keep solution in the spray tank overnight.

- Follow the label and DPR procedures for disposal of all empty pesticide containers. Under no circumstances should empty pesticide containers be converted for storage of other materials.

- Pesticide applications should be limited to the smallest reasonable area, utilizing such strategies as spot treatments if possible.

- Time applications to treat insects in the juvenile stages when they are the most vulnerable and when desirable insect species are less vulnerable to maximize effectiveness and reduce the necessity of future applications.

- Avoid applications before forecasted rains to prevent leaching or off-site contamination by the pesticides.

- Do not spray if winds are sufficiently strong to cause drift. Drift can also be reduced by lower-pressure applications. Avoid excessive spray tank pressure. Use a larger nozzle size to reduce misting and subsequent drift of the spray solution.

- Check the label to see if a spray adjuvant improves the efficacy of the pesticide application.

- Purchase a small pH meter to insure the solution in the appropriate pH range. A recommendation for the correct pH ranges may be on the label. If not, check with the distributor's representative.

Insecticide Categories

Inorganics

- One of the oldest types of pesticides
- More widely used in structural pest control
- Often called "minerals, because they are mined and then refined before packaging
- They have a slow killing action
- Examples: boric acid, silica aerogels, diatomaceous earth, dry clays

Organics

Organics are pesticide compounds that contain carbon as part of their molecular arrangement

Types of Organic Insecticides

- Botanicals
- Pyrethroids
- Chlorinated Hydrocarbons
- Organophosphates
- Carbamates
- Fumigants
- Growth Regulators
- Attractants
- Repellants

Botanicals

- Derived from plants and sometimes referred to as "natural pesticides"

- Examples are rotenone, pyrethrum, and nicotine
- Pyrethrum is the most widely available
- It is an oily substance extracted from chrysanthemum flowers
- Used in combination with a synergist
- There are at least 6 distinct pyrethrum molecules

Pyrethroids

- Synthesized from the various pyrethrum molecule structures are compounds call “pyrethroids”
- Generally have some sort of improved action compared to natural pyrethrins
- Synergists may not be needed
- These compounds may not offer the low-toxicity advantages of natural pyrethrins.

Chlorinated Hydrocarbons

- First group of synthetic insecticides to gain common usage
- These chemicals offer broad-spectrum insect control
- They have the advantage of long residuals
- Best known is DDT (banned in 1971)
- Another example is Chlordane (also banned)

Organophosphates

- First insecticides to replace the chlorinated hydrocarbons
- The primary toxic action of OP’s involves the inhibition of cholinesterase, an enzyme in the nervous system
- Humans are susceptible to this mode of action and can be harmed by these compounds
- Early OP’s included dichlorvos and Parathion – today’s OP’s are less toxic

Carbamates

- Carbamates have similar mode of action to that of OP's
- Examples of carbamates in carbaryl (Sevin), propoxur (Baygon), and bendiocarb (Turcam)
- These compounds are generally safer than OP's
- Caution: carbamates have a high toxicity to bees

Fumigants

- Fumigants are toxic gases or vapors
- Mode of action is to bind with enzymes in the target organism
- Have a very low residual
- Often they are highly toxic to humans
- An example of a highly toxic fumigant is methyl bromide

Insect Growth Regulators

- Generally have a low toxicity to mammals
- They can work in a number of ways
- They can mimic the action of hormones
- They can disrupt normal development
- They can cause sterility in the target organism
- They can affect the cuticle development in insects

- Attractants and Repellants

- Fast growing segment of pest control
- Attractants are often used to monitor insect population
- Pheromones are an attractant, and sometimes a repellant, that communicates within a species
- Semiochemicals are used to communicate between different species

Pesticide Formulations - Liquid

Emulsifiable Concentrate (EC)

- Characteristic: Diluted with water to form milky or clear liquid for spraying
- Advantage: ease in mixing and application, little agitation is required, and leaves minimal residue
- Disadvantages: easily absorbed through skin, solvents can cause sprayer parts to corrode, and phytotoxic to plants
- Example: Betesan 4E

Solutions (S,SL, L)

- Characteristic: Solution in water or oil, forms a clear liquid for spraying
- Advantages: Forms a true solution, no agitation is required
- Disadvantage: Can be hazardous to mix, and mixing rates can be difficult
- Example: Carbaryl 4L

Flowables (F, FL)

- Characteristic: Mixture forms a suspension when mixed with water
- Advantages: easy mixing, allows use of difficult to formulate chemicals, can combine characteristics of advantageous carriers
- Disadvantages: Exotic sovents required are sometimes expensive, Settles in tank, must be agitated
- Example: Mancozeb 4F

Flowables microencapsulated (FM)

- Characteristic: Active ingredient is encased in tiny plastic capsules, which are suspended in in water for spraying
- Advantages: Lengthy residual activity, low in toxicity, do not break down in water
- Disadvantages: Usually more expensive, constant agitation required, leaves a visible residue on some surfaces

Fumigants

- Characteristic: Active ingredients are sometimes gases which become liquids when packaged under pressure. They revert to gas form during application. Others are volatile liquids that become gas when released.
- Advantages: Toxic to wide range of pests, penetrates well and usually controls pests with one treatment
- Disadvantages: Treatment area must be enclosed, highly toxic to people

Pesticide Formulations - Dry

Wettable Powders (WP)

- Characteristic: Usually contains 50% or more active ingredients. Powders do not dissolve in water but remain suspended
- Advantages: Compared to EC formulations- better residual on porous surfaces, Lower phytotoxicity hazard, less prone to skin and eye absorption
- Disadvantages: Inhalation hazard when mixing, requires constant agitation, residues may be visible
- Soluble Powders (SP)
- Characteristic: Similar in appearance to wettable powders, but readily form a true solution in water
- Advantages: Same as wettable powders
- Disadvantages: Inhalation hazard while pouring and mixing concentrated powder

Dusts (D)

- Characteristic: May be 100% active ingredient – or carried on dry particles (inert clay or talc)
- Advantages: Ready to use - no mixing, long residual when dry
- Disadvantages: Difficult to apply uniformly, drifts easily, and may leave visible residue

Granules (G)

- Characteristic: Particles are larger than dusts, generally have low active ingredient (1% to 5%)
- Advantages: Easy to apply, ready to use – no mixing, low drift hazard, provides longer residuals than WP or EC materials
- Disadvantages: More costly than WP's or EC's, may require moisture to activate the pesticide ingredient, can be picked up by birds

Water Dispersible Granules (WDG)

- Characteristic: Particles are often incorporated into clay or other materials which are readily broken down in water
- Advantages: Easy to measure and weigh, safer to handle than dusts or wettable powders, and they go into solution quickly
- Disadvantages: Clogs sprayer parts, abrasive to sprayer parts, shelf-life is not as long as other products, and they are more costly

Baits (B)

- Characteristic: Active ingredient is usually less than 5% and is mixed with food or other attractive substance. May be solid or liquid.
- Advantages: Ready to use, long residual activity, pest will seek out bait - reducing the need for dispersion
- Disadvantages: May pose hazard to non-target organisms, must out-compete available food, dead pests can smell and be hard to locate

Fumigants

- Characteristic: Tablets or pellets. Fumigant is slowly released as a gas
- Advantages: Easy to handle, low toxicity hazard
- Disadvantages: Requires a relatively long fumigation period
- Examples: Napthalene,Phosphine