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Trees & Turf: Managing Mutual Performance Values

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Both tree and turf cultural systems strive for great plant performance, high landscape values, and exceeding client expectations. Management of either trees or turf requires similar knowledge of sites and soils, plus additional unique knowledge of specific biological and ecological reactions. Health care and structural maintenance of both tree and turf systems call for specialized knowledge. When trees and turf are required to effectively meet management objectives growing on the same site, additional knowledge and efforts are required to allow both to thrive.

Separations

Clearly trees and turf can not grow on the same point. There is a separation in nature between trees and turf which varies by the amount and quality of the resources each can gather and control. The less intense and extensive management remains, the more tree / turf interactions are governed by ecological processes. Under extreme resource limitations, tree / turf site occupancy can be clearly differentiated at the soil surface as a root interference zone and in the leaves as a light gathering problem. As management becomes more intensive with resources added to a site to hold it away from ecological equilibrium, and assure plant performance, interference between trees and turf become more concentrated.

Ecologically, all plant systems must use the same set of resources to live. In locations where essential resources are not limiting, optimal growth can occur for every living thing. Unfortunately, the economics of scare resource allocations among different living things are an universal problem for which different plants approach solutions in different ways. To propel their gene sets forward in time, a host of strategies have developed: tall, short, perennial, annual, biennial, woody, succulent, wind-pollinated, insect-pollinated, monoecious, dioecious, massive, tiny, etc. Trees and turf have each found success in wildly different strategies of life even though they require nearly the same essential resources.

Growing Out & Up

Trees continue to exist by shedding inefficient parts externally (like leaves & twigs) and internally (like heartwood & compartmentalization). Trees grow by physically advancing their position each growing season through elongation and expansion. Trees establish a new sheath of living tissue over the old exterior of living tissues every growing season. Trees sense and react to changes in their environment at shoot tips, root tips, and the vascular cambium (boundary between xylem / wood and phloem), and the phellogen (boundary between secondary cortex and periderm). Living tissue on the outside of twigs, stems and woody roots (just beneath the phellogen) are the most active, reactive and responsible for a tree's biological success, as well as for maintaining structural integrity.

Trees grow and expand their ecological area of influence by interference (which is a combination of competition and allelopathy,) and by structural expansion (increasing the extent and reach of resource gathering systems). The elevation and distribution of tree leaves is a strategy to capture and control all photosynthetically active radiation coming from sunlight while maintaining biological and mechanical efficiency. The initiation and elongation of tree roots is a structural strategy to gather and control essential soil-resident resources while sustaining ecological dominance. Figure 1. Root expansion growth is shallow, extensive, and continuous. Roots greatly expand the soil area controlled, compared to stem and crown expansion over time.

Growth

Trees get bigger each year. Over a number of years, the growing space requirements adequate for a small tree will be too limiting for a medium sized tree. Crown expansion usually reaches a structural equilibrium on each site in reach and extent. Tree stem and root expansion continues over the years. Either planning for growth and expanding surrounding critical rooting space area over time, or beginning with an oversized critical rooting area which a tree can grow into, are two means allowing tree growth.

Rooting Out

Tree root systems have a high oxygen demand, are shallow, and can extend hundreds of feet away from a tree. There are three main tree root colonization areas (Figure 2) surrounding any tree stem base:

1) structural root area or root plate (tree diameter in inches measured at 4.5 feet above ground multiplied by 0.9 which equals the diameter of root plate in feet);

2) primary occupation and resource gathering area (tree diameter in inches measured at 4.5 feet above ground multiplied by 2.5 which equals the diameter of primary resource gathering area in feet or the Critical Rooting Distance -- see Figure 3); and,

3) active interference and exploration area (tree diameter in inches measured at 4.5 feet above ground multiplied by four which equals the diameter of root resource exploration area in feet).

Figure 4 represents a critical rooting distance around a tree of a given diameter (dbh), as calculated above. The distance between a tree and the edge of its critical rooting area is divided into five equal distances. The percent rooting area disrupted by encroachment or damaged, as the stem base is approached are given. For example, any damaging site change or treatment which approaches a tree 2/5s of the way inside its critical rooting area would damage 64% of active roots. Usually no more 33 - 40% of critical rooting area can be damaged before an otherwise healthy tree begins to show severe decline symptoms.

Living Together

The plight of planting trees and turf together is a perceived decline in performance of both. The resources which both trees and turf require must be gathered, controlled, and effectively utilized in a ecologically efficient way. A tree with limited growth development space placed in a turf dominated area will be stressed by the limited resources available. Turf placed in a space dominated by active tree root colonization and light filtering will be stressed by the limited resources available.

Both trees and turf will attempt to gather resources before the other can gain control (competition) or insert an ecologically active agent into air, water, or soil which prevents gathering of resources (allelopathy). Allelopathy can become more noticeable when competitive forces of interference are not as effective in gathering and controlling resources. Interference between trees and turf can be severe and disrupt effective management of a landscape with combined objectives.

For example, one study (Griffin et.al. 2007) with two tree species and three common turfgrass species (two cool-season & one warm-season) found turf greatly stressed trees. In just two growing seasons, removal of turf interference allowed for twice the diameter growth of trees. With no turf interference, this study found tree weight (of root, stem, crown, and leaf components) increased an average of 250% over turf stressed trees.

Refereeing

Tree / turf management ideally requires a complete separation of resource bases. Separating the combatants is an easy way to have both in a general area without having to compromise management of either. Complete separation is difficult to accomplish in small spaces and for many landscape objectives. Many people perceive the ideal landscape as intermixed species and plant forms, and demand the same performance in multi-culture as in mono-culture. To meet client expectations, a landscape manager is forced to compromise plant performance and values to reach a management optimum incorporating both trees and turf.

Combination Environments

Changes in the mutual environment of tree / turf culture are concentrated around:

A) Light Resources – Quality, quantity, duration, form, shade, litter;
B) Moisture Content – Relative humidity, dew retention, evaporation, water infiltration, and water runoff;
C) Air Movement – Wind velocity, advected heat, air turbulence;
D) Temperature – Air temperatures, soil surface temperature; and,
E) Soil Resources – Oxygen, compaction, essential elements, element availability.

In addition to the physical features of the growth environment, any landscape management environment can generate a number of negative impacts including neglect and abuse through ignorance, landscape machinery damage, and health maintenance practices targeted at one plant system which damages the other. Both budget and evaluation of success in a managed tree / turf system must be carefully defined. Trees and turf can live in the vicinity of each other and maintain great aesthetic and biological performance values. The closer they grow together, the more compromises must be made in the management of each. Trees will need more care in turf dominant situations to prevent loss of tree values, to decrease liability risks, and to prevent tree death.

Light of Life

One key concern in sustaining top performance in tree / turf culture is the effective management of light energy. Trees paint turf with highly variable shade patterns. Figure 5 demonstrates the changing sun position in the sky over the growing season. Mapping shade patterns opposite the sun across any tree (or obstacle) is key to understanding shade impacts.

Attempt to draw onto a landscape area a shade field where, as the sun moves during the growing season, shade is projected onto other plants and the soil surface. Depending upon whether this shade field is primarily direct shade, diffuse shade, or mainly sunflecks will determine how well other plants will perform on the site. It is important to understand the shading process in order to effective manage trees and turf on any site.

PAR!

Light resources on a site are critical to powering plant life. In tree / turf culture, it is the arrangement of light absorbing arrays (leaves) in trees which can prevent turf from receiving enough light for surviving or thriving on a site. It is estimated 25% of turf acreage in the United States is under shade. The definition of shade used here will be the filtering or blockage of light of physiologically active wavelengths. Approximately 50% of all incoming solar radiation is in the wavelength range of 400-700 nm (called photosynthetically active radiation (PAR)).

Of this PAR, which corresponds roughly to the blue and red ends of the visible spectrum of light, only about 1% is used in photosynthesis. All plants use PAR to make food (carbohydrate (CHO)). If photosynthesis rates drop below tissue respiration requirements, plants decline and die. A positive net photosynthesis rate must be maintained or plants will not be able to sustain themselves against other plants and the environment. To maintain a positive net photosynthetic rate requires effective capture and use of the energy in PAR coming from the sun.

C3 & C4

As PAR strikes and passes through leaves, a minimum level of light is required to activate the photosynthesis machinery. The more PAR, the greater the photosynthetic rate up to some maximum rate. PAR above this amount does not provide any more value to a plant. The maximum light which can be utilized depends upon each plant's photosynthetic equipment and its maintenance. Trees and cool-season turf use one type of chemical machinery called C3, while warm season turf use a C4 process. The C4 process can utilize much greater PAR levels and function well at higher temperatures compared with the C3 process.

C4 turf has good water use efficiency, strong photosynthesis rates across many warm and hot temperature conditions in full sun. C4 turf optimum photosynthetic rates are reached near 90^{o}F. As PAR drops to 80% of full sun, C4 plants begin to have problems. As PAR drops below 55% of full sun, major problems become evident. Most C4 plants are not shade tolerant, but can perform well in limited shade especially if the shade is enriched in blue spectrum light (diffuse sky light). C3 plants like cool-season turf reach a photosynthetic optimum around 75^{o}F and can tolerate PAR levels down to 35% of full sun. There are many shade tolerant cool-season turf grasses.

Light Power

There are several wavelengths of light which are actively sought by photosynthetic systems. Generally the light spectrum is divided into blue range (B = 400-500nm), green inactive range (G = 500-600nm), red range (R= 600-700nm), and far red range (FR = 700-800nm). Figure 6. The blue range is active in powering photosynthesis and is found in direct and diffuse sunlight. The green range is generally not used by plants and is reflected or passed through to our eyes. The red range is also used in powering photosynthesis and is found in direct sun light. The far red range is used to measure light quality by plants, and affects growth control processes when measured by a sensor pigment called phytochrome.

Tree leaves act as selective filters on incoming sunlight. Tree leaves remove portions of the PAR for use in food production. The more leaves filtering the sun, the less energy available for capture below and the deeper the shade. Blue and red wavelengths of light are used, leaving remaining green colors to paint shady areas. Most full sun plants require at least six hours of full sun every day even if they spend the rest of a day in shade. Perpetual or constant shade is a low energy, stressful environment. Sunflecks are short duration points of light which deliver full sun for periods of 2-10 minutes. Some plant species depend upon these bursts of full sun to survive and may not be able to survive perpetual shade.

Twin Chlorophylls

There are two primary forms of chlorophyll in higher plants – chlorophyll a (Chla) is a full sun pigment and chlorophyll b (Chlb) is a shade pigment. Both are usually present in all leaves and the proportion between the two shifts with changing light resources. Chlb is more efficient at processing PAR which has already passed through other leaves. Chla is more effective capturing (absorbing) direct sunlight. Figure 7. Chla is best at collecting light wavelengths of 410, 430, and 660 nm. Chlb is best at collecting light wavelengths of 435, 455, and 640 nm. There are a number of accessory or protective pigments (carotenoids and xanthophylls) which collectively absorb light wavelengths around 450nm.

The ratio between Chla and Chlb has been used as a shade stress indicator. The more Chlb present, the more shade stress is challenging a plant. Over time, the chlorophyll ratio has been found not to discriminate well for quantifying shade stress. A newly proposed shade stress measure is determining violaxanthin contents. The xanthophyll pool of pigments in leaves changes with light quality and from day-to-night. Light causes violaxanthin to be processed into zeaxanthin in turf. At night the process reverses. There currently is no easily determinable means to estimate shade stress other than visual decline symptoms.

Shade Types

Shade comes in many different forms. Shade varies by duration, timing, density, and source. Light perpetual shade can be more damaging than six hours of heavy shade. Morning shade has been shown to be worse for turf than the same duration of shade in the afternoon. A dense shade has much less energy to power photosynthesis than a light or spotty shade. Sunfleck number, size, and duration variations can mean the difference between decline and thriving.

Buildings and awnings produce a different quality of shade than tree canopies. Building shade tends to be richer in B and less FR than tree canopies. Tree shade is enriched in FR and short of R from leaf filtering. Because FR initiates tree growth changes, shade quality differences from different shade sources affect plants differently.

The shade behind a leaf has two components, a full shade where no direct light is available and a partial shade where more diffuse and scattered light is available. Based upon the diameter of the light emitting disk of the sun in the sky and its distance from a leaf, a cone of full shade called an umbra exists for a given distance behind the leaf. (Figure 8) Proper terms for these shade areas behind or below a leaf are given in Figure 9. This full shade or umbra cone exists for a distance of approximately 60 times the effective leaf diameter (ELD) of a leaf. Each leaf has a different effective leaf diameter.

ELD & DSED

Effective leaf diameter (ELD) is the average of short and long axis length for the largest ellipse which can be scribed within a leaf which does not cross any leaf edge. Figure 10. Here each leaflet will be considered the same as a leaf. Figure 11 provides a definition of effective leaf diameter for various leaf shapes. Effective leaf diameter in inches multiplied by 60 yields the direct or full shade effect distance (umbra length or DSED) behind the leaf in inches. Leaves in bundles (pine needles) should have effective leaf diameters calculated by bundle diameter not by single needle width.

Table 1 provides a list of tree species and their average effective leaf diameters and direct shade effect distance (DSED) behind or below a leaf. Note that the DSED is not a vertical umbra distance, but an umbra which moves behind a leaf as the sun traces an arc through the sky. This arc will never be vertically above the leaf at any latitude greater than the tropics, but always at some angle less than 90^o to the horizon.

Direct or Indirect?

Figure 12 shows the effect of distance below a leaf upon the quality and quantity of the shade produced. Leaf layers create complex patterns of direct and diffuse shade at any one moment in time. The soil surface beneath a tree will be a mix of direct (full) shade, diffuse (partial) shade, and sunflecks (short duration full sun). Table 2 shows the direct shade effect distance (DSED) behind or below leaves with various effective leaf diameters. For example, a leaf with a four inch effective leaf diameter (4" ELD) directly influences sunlight below/behind for 20 feet (umbra length or cone of full shade or DSED = 20 feet).

Few plants will perform well in direct full shade. Tree pruning using crown raising and crown thinning can help improve light resources below. Note some trees (magnolia and holly as examples) have values in the landscape and growth patterns (low branch skirts) which preclude attempting to increase DSED with crown raising.

More Interference

Tree shade has a significant interference effect on turf. Coupled with shade stress are other components of interference. Root competition between trees and turf is great. Competition for resources and the allelochemicals generated constrain each plant type. Turf culture suppresses tree rooting density by 90% and initiates tree rooting closer to the soil surface. If compaction or over-watering has effectively raised the 5% oxygen content soil depth threshold within the soil closer to the surface (called the dead zone), tree roots may grow on the soil surface. Turf growth, and residues produced (thatch), limit oxygen movement into soil and to tree root surfaces.

Another type of interference present in tree / turf culture is the acceptance of vines and epiphytes. Traditional landscapes with large tree and turf values may also use ivy, jasmine, grapes, Virginia creeper, or other woody vining plants at the base of trees. The interference from these plants as shaded ground covers is not as intense as turf. When vines are allowed to climb trees into the sun, they use more site resources, especially light and water. Vines present both ecological interference and mechanical support problems (in wind and ice storms.) Some epiphytes like Spanish moss do not actively interfere with tree roots and soil resources, but physically block light from tree and turf foliage. Periodic control and removal is needed.

Compromise

For best performance, light resources must be carefully managed to assure trees are not damaged and accelerated to decline and death, and turf is not starved of light and burdened with serious disease problems.

Compromise in all aspects of cultural activities may be needed. Trees will require more care in turf culture situations to maximize values generated and minimize liability risks. A management optimum which provides adequate resources for both trees and turf will change week-to-week and season-to-season. Multiple solutions may exist for the same management problem, with solutions constantly requiring modifications.

Water Problems

One set of environmental factors greatly modified in tree / turf culture is the distribution, changing physical states, and dissipation of water. Almost all water enters plants in a liquid phase brought by condensation, precipitation, irrigation, or resident in soil pore spaces. Water evaporates from soil and plant surfaces. This evaporation from leaves is needed to assure an adequate supply of water for the photosynthetic machinery and for dissipation of heat.

Trees run at or slightly above air temperature when water is available. Lack of water leads to an elevation of leaf temperature, additional water loss, and cessation of food making. Less site water availability for evaporation from soil surfaces mean an increase in heat loading on a site. Increasing heat load can damage plants, initiate a number of drought symptoms, and greatly decrease the relative humidity of the air (accelerating potential loss of water which is already in short supply).

Disease Problems

For best performance in turf and many other landscape plants, minimizing the duration foliage surfaces are moist minimizes pests. Fungal diseases in turf are especially increased in extent and severity by a lack of air flow removing high humidity air and dissipating water through evaporation of dew and of foliage-resident water deposited by irrigation or precipitation. Irrigation timing which increases the total continuous hours of wet foliage can geometrically increase disease problems. Tree shade and blocking air flow can increase dew retention periods even though dew is less under trees.

Once foliage is wet, it cannot functionally become any more wet for disease initiation and attack. Relative humidity under trees remains much higher for longer periods of time, increasing disease presence in turf. Remember, plants in full sun utilize large amounts of any available water while plants in shade need much less. Over-watering turf is a common error under trees and can lead to poor turf performance, disease problems, and anaerobic soil conditions damaging turf and tree roots.

Mulch Blankets

Mulch can be made of many materials. A well sorted, graded, and washed organic mulch has many advantages around a tree. Mulch insulates the soil surface from light, conserves water, and modifies temperatures favorable for tree roots. Mulch can help provide an area of separation between trees and turf, and associated maintenance equipment (string trimmers, aerators, mowers, etc.) Mulch should be used in the shaded areas of a landscape. Mulch in full sun reflects more heat onto tree tissues than turf, but much less than pavement.

Turf removal from around a tree can yield 10-20% more active tree roots. Turf removal and thin mulching can yield 80-100% more active tree roots. Mulch is preferable to a turf / herbicide program because of potential interference and nontarget pesticide damage. Mulch instead of turf use under and around trees, modifies branch angles and tree growth regulation. Narrower branch angles (more upright branches) occur in young trees surrounded by turf. Turf interference initiates cytokinin (a natural tree growth regulator in roots) changes which lead to branch angle changes and food allocation problems.

Tucked In

Mulch should be placed around a tree in an area with a minimum radius of four feet. Remember to keep the first 1/3 foot (4 inches) of radius at the tree base completely clear of mulch. Expand the mulch radius ½ foot for every inch of tree diameter measured at 4.5 feet above the ground. (Table 3) Mulch thickness will depend upon its packing density and fine particle content. Strive for larger coverage and thinner (~1.5-2.0 inches) rather than for less area covered and thick piles or layers. A thin (<1/2 inch) woody compost layer can be placed on the surface of the soil with a thin natural organic mulch placed on top. Figure 13.

Soil Compaction

Construction practices and use of a site may limit effective tree and turf management. Construction activities injure living tissues, disrupt structural integrity, and damage essential resources. Soil changes can be highly constraining to tree and turf performance, especially soil compaction processes. Any machine, animal or human can compact soil quickly across a landscape. Figure 14.

Simply mowing turf generates a management compaction layer (pan) at some distance below the surface depending upon tire / tread impact pressure and soil moisture content. The first few passes over the same point of moist soil can compact soil to within 90-95%. Soil compaction results from not many years of moving over a site, but the first few contacts which compacted the soil. Decompaction is needed, not generic aeration, to alleviate compaction associated problems.

Dead Zone

At some distance below the soil surface, the presence and replenishment rate of atmospheric oxygen declines and becomes functionally anaerobic. This point is where oxygen for plant root aerobic respiration becomes limiting (~4-5% oxygen content as measured O_2). Tree root activity is directly dependent upon soil oxygen concentration as associated with soil texture and drainage. Figure 15.

The oxygen limitation layer can be raised or lowered in a soil by compaction, watering, organic matter additions, surface crusting, or anything which would change water infiltration or water holding capacity, and/or oxygen flow and use. One useful management model to demonstrate soil changes is the concept of a dead zone which moves closer to the soil surface as soil oxygen is limited by management. Figure 16 defines the changing depth of the dead zone with soil compaction.

Stirring It Up

Some turf establishment and maintenance procedures require tillage or disruption of the surface soil where active tree roots are concentrated. Most tillage uses knives, discs, or tines to move soil around adding aeration pores and minimizing constraining layers in soil. These harsh tillage processes severely damage tree roots. Soft tillage using water or compressed air minimize root damage and still move soil around. Air driven guns work best when tillage around tree roots is needed, if water is added to the site immediately after air tillage.

Continued use of shallow (<3 inch) turf aeration tend to maximize turf performance and minimize tree performance. Turf is positioned and designed to take advantage quickly of new and reshuffled resources. Turf tends to effectively interfere with tree roots in the continually aerated areas, generating a denser (and more constraining for tree root growth) rooting zone near the surface. In addition, turf equipment used for aeration leaves a compacted zone in the soil below based on soil moisture and tire/soil pressure exerted.

Cut, Mash, Suffocate

Construction activities in tree and turf culture can lead to permanent and irreversible plant and site damage. Grading, cuts, fills, tilling, and discing damages tree roots directly by mechanical impact, or biologically through preventing gathering of essential resources. In intensively managed tree and turf areas like recreational sites, simple hardscape amenity improvements can have devastating impacts on trees. Any turf damaged can be readily replaced, but large trees severely damaged cannot be replaced in three generations of managers. Trees are not easily, nor cheaply replaced, therefore prevention of damage is essential.

It is important to remember trees cannot "heal" injuries. Trees seal-off damage and grow on and over any wound. Once damaged, trees remain damaged till death. Tree reactions to wounding can, in some cases, accentuate the original injury leading to catastrophic failure in the future. Most of the internal volume of a large tree contains no living cells, these cells having been sealed-off from the rest of the tree in a tissue type called heartwood. Just underneath the periderm and in the most recent few annual growth increments, are living cells responsible for life and mechanical support of a tree. Any form of damage to the circumference of woody tree parts will have serious implications to tree function and site risk management.

Nitrogen Temperance

Fertilization is generally required in tree and turf culture in order to attain and maintain the best plant performance. The interaction of the two plant systems require careful restraint in fertilization. Over-fertilization with nitrogen of tree / turf sites lead to more pests, especially on turf, and loss of ecological resiliency to react to stress conditions due to stored food reductions especially in trees. Good pH management (>5.5 & < 6.5 pH) is important. High levels of potassium availability is essential for tree / turf combinations, especially the wear on turf.

Nitrogen requirements of turf is greatly reduced under tree interference. Generally, turf fertilization under trees should be cut back to less than 50% of normal full sun turf fertilization rates. Fall fertilization after tree leaves have fallen and raked allows turf to utilize applied nitrogen effectively. Inject a fast release, soluble fertilizer with a 4-6 inch deep injector. Apply fertilizer to mature tree / turf areas with a ratio of 2:1:3 NPK. Fertilize young tree / turf areas with a ratio of fertilizer of 3:1:3. NPK.

Herbicides

In modern high performance landscapes, many ecologically active inputs are required to meet client expectations. Many of these treatments or inputs make the site unsustainable and ecologically unstable. Key among these inputs may be turf performance enhancing chemicals, particularly herbicides and growth regulators targeting weeds or turf growth rates. All these chemicals must be vetted for potential tree damage before use. Some chemicals can seep through drying cracks in soils or through expansion joints in pavements, directly reach living tree tissue, causing damage.

Pruning For Effect

Trees can be effectively managed for increased light passage through crowns by reducing foliage density. Two pruning methods used to reduce shade density are crown raising and crown thinning. Crown raising is properly pruning lower branches. The distance to leave between the lowest live branch and soil surface can be estimated by calculating average shade effect distances. Raising allows more blue band light to diffuse onto turf and more total light passing through the tree crown. Crown thinning is removal of foliage-bearing branches and twigs within the living tree crown, but not affecting total reach and extent of the crown. Thinning can allow more sunflecks of full sunlight, and more total light, to reach turf surfaces.

Key features of pruning trees to positively impact turf and maintain tree health include:

1. no wound paints;
2. remove basal, stem and branch sprouts as they appear;
3. defend the stem-branch collar area by proper target pruning;
4. no flush, stub, or tip cutting;
5. no topping or internode cuts;
6. begin training trees as soon as possible to prevent problems later in life;
7. allow young trees multiple growing seasons to become established; and,
8. do not prune an individual tree every year -- prune once every 3-5 years.

When raising tree crowns prevent abusive pruning levels (Figure 17) from removing too much foliage. Strive for maintaining a living crown ratio of greater than 65% ideally. For intensive managed mature tree / turf areas, establish a minimum pruning clearance of 8-12 feet above the ground on appropriate species to allow more light resources below, while reducing maintenance and visibility problems.

Pruning Underground

Tree / turf culture can be successful when the two plant systems are segregated. Zoning separate areas for water, fertilization, pest treatments, and soil colonization allows a great deal of separation where each plant type can approach its best performance. Separating interference zones both above and below ground is critical. Crown pruning can control shade effect distance and shaded area, while root pruning and root barrier installation can help maintain separate root interference areas.

Installation of root barriers in soil act as edging does above ground – to clearly separate tree and turf areas. There are a number of commercial root barrier products on the market which include a chemical cloth system, a heavy locking plastic system, and a wide variety of other root barrier forms. Installation of a root barrier begins with planning resource volumes and values available to trees and turf. The more separation space allowed, the better for each.

Surface Rooting

Some people notice roots on the surface of soil. These roots are usually prevented from deeper growth and development by poor soil aeration and compaction. Surface roots have no place to go in the landscape. Mowers, vehicles and foot traffic can all seriously damage surface roots. Root pruning is usually not recommended until after a site has been restored to healthly soil conditions. Limited (1/2-1 inch depth) soil fills with coarse textured materials covered by a normal mulch and compost blanket can lift equipment and foot steps over roots.

In some cases, large roots have existed on the surface for many years. These roots are usually in the root plate area of a tree and subject to up and down movement from wobbling of the root plate in wind. A root one inch below ground when young may grow to break the surface and continue to expand in diameter growing well above the surrounding soil surface. Large roots regardless of their size are still more buoyant in soil than soil minerals. These large roots moving, growing, and buoyed up tend to break and extend above the soil surface leaving them prone to top damage. Sometimes continuing damage occurs as each mower cycle shaves off more tissue.

More Root Space

It is critical to allow enough room for tree root systems due to their dual role in absorbing essential elements and structurally supporting a massive tree under dynamic wind loads. No activities should be designed for the root plate or structural rooting area. Large rooting volumes mean healthy and structurally sound trees. Root pruning for installation of a root barrier should be completed minimizing twisting, pulling and tearing of roots, and to assure minimal root surface area exposed.

Thin Is In

A major problem in many intensive tree / turf cultures is the perception that more trees are better than fewer trees. It is aesthetically better to have a few, great impact, structurally sound, and biologically healthy trees than many stressed, pest ridden, and poor quality stems. Trees grow and occupy more space over time. A group of trees planted for a specific shade impact can grow and over-occupy a site. Thinning trees is a good management tool because it removes the poorest trees, leaves the best trees, and releases new resources. Overcrowding or overstocking leads to premature death, increased pest problems, and less resistance to site stress among trees.

Two means of gauging overstocking of tree stems on a site is using a PAR light meter, or measuring the effective basal area in square feet of a site. The PAR meter will demonstrate how much usable light is present (or could be made available) through tree thinning. Basal area measures are an easy means to determine stocking levels and measure thinning impacts. Basal areas between 30 -- 60 square feet per acre (measured with a prism or angle gauge) are appropriate for a tree covered area. Basal areas between 20 -- 35 square feet allow better turf performance while still having a tree component.

Planning Success

Tree planting is usually poorly planned in tree / turf areas. Putting a particular species of tree in any open spot just because one is available (i.e. the tree and the spot), is poor management. Trees properly designed into a landscape can provide great benefits. Examining regional tree selections and availability for planting is critical for successful tree / turf culture.

Select trees which minimize litter problems. Tree litter is composed of leaves, twigs, bud scales, fruit, flowers, cones, or periderm which cover the soil surface beneath a tree and can blow onto surrounding areas. Some trees produce much litter while others do not. Some trees have leaves which rapidly break down and decay, while other tree leaves dry to a crunchy, ground hugging blanket which stays in place all Winter. A strong Fall raking program is essential.

Tree Planting

Tree planting requires an attention to detail in how a tree is selected, handled, installed, and cared for after installation. Problems at any point in the tree selection and planting process will result in poor performance as well as confusion regarding causal agents of poor performance.

Key features of tree planting in tree / turf culture include: Figure 18.

1. use a mulch island or pull back turf as far as reasonable for at least the first three growing seasons;
2. always err on planting the tree too high (1-2 inches) rather than planting level with the soil surface or low in the landscape;

3. water trees over root ball;
4. most trees do not need staking and guying;
5. always lift by the root ball never by the stem base;
6. do not roll or drop the root ball;
7. remove all wires, ties, ropes and cables from the tree at planting time;
8. use native soil from the saucer to refill the planting saucer; and,
9. do not root or branch prune the tree for several growing seasons.

Health & Structure

Great tree performance entails strong intervention to assure resources are available for tree growth and health. In addition, great tree performance requires consideration of tree structure. Trees exist for many decades or centuries, standing against storm, gravity, and a conspiracy of various injuries and faults. Because of individual values of trees, and their mass and volume, structural maintenance is sometimes needed. Chief among structural additions are braces, cables, and guys. These are primarily metal objects attached to stem, roots and branches which control movement, exert force, or prevent tissue failure. Structural remedies for potential failures in trees are installed by specially trained arborists.

Lightning conduction and tree protection systems should be considered in large trees where people or animals could shelter beneath in a storm, or for historic or culturally significant trees. Lightning conduction systems in trees influence all other lightning protection devices and grounding means for all electronic equipment in the area including buildings, irrigation systems, wells, and utility installations. Seek professional tree protection specialists for assistance.

Risk Assessment

Associated with proper pruning and structural maintenance on mature landscape trees is the recognition of faults, cracks, pests, and injuries from root tip to shoot tip. Professional care assures the best performance of trees. Remember, turf does not fall and kill people, trees do. A tree risk management program is essential in tree / turf culture. Hazard recognition and removal, as well as storm damage assessments, should be part of a tree inventory and treatment programs. In intensively managed tree and turf landscapes, beautiful turf performance entices people under the overhanging branches of trees, some of which could pose a liability risk.

Conclusions

Management of trees and turf together is challenging.

Compromises in the culture of each must be made if both plant systems are to attain best performance.

Trees will need more attention in turf dominant situations to prevent injury, pests / stress, and declining performance. See **Figure 19.**

Seek professionally credentialed tree health care providers (i.e. arborists and community foresters) for any tree component of a great landscape.

Citation:
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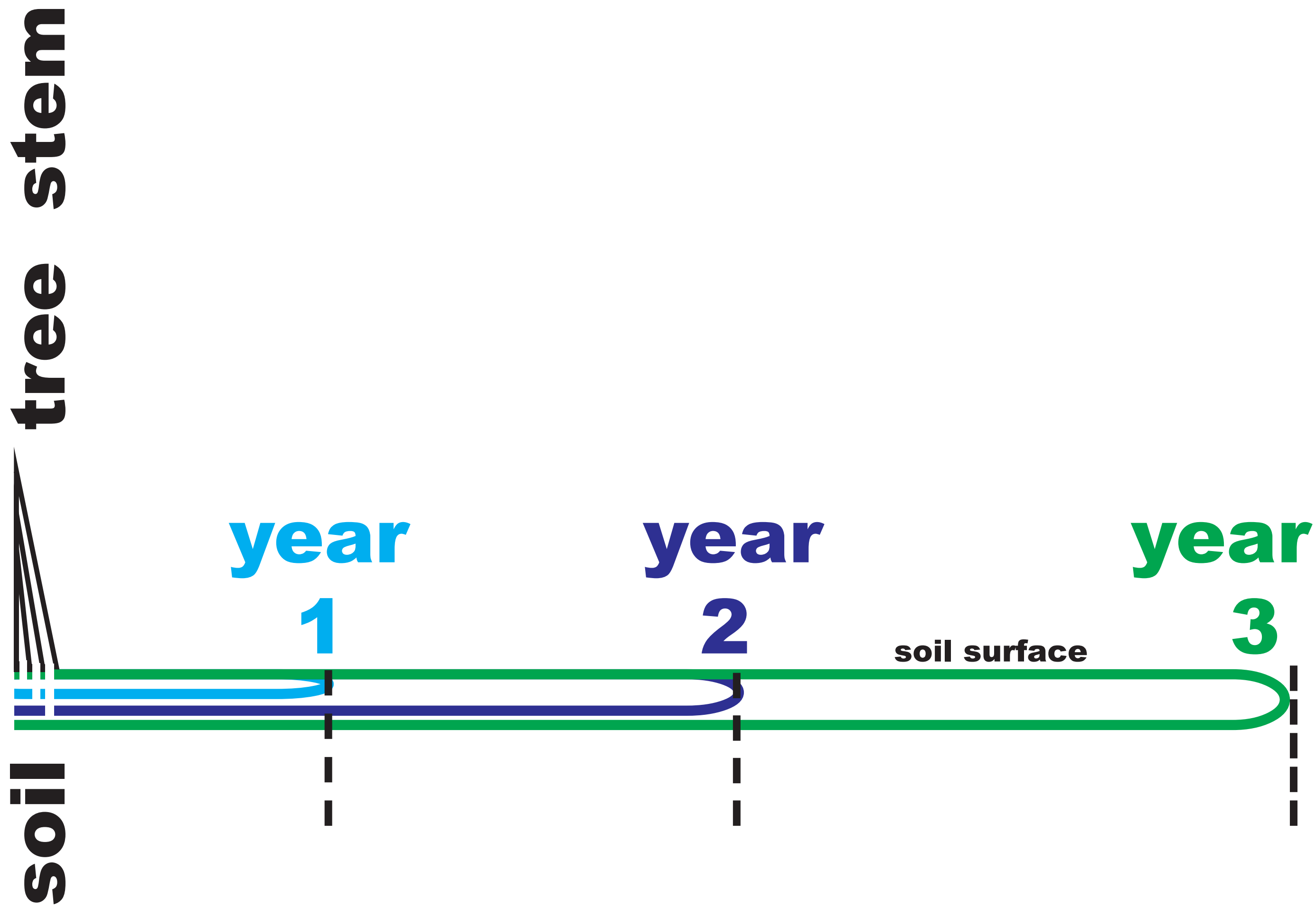


Figure 1: Side view of tree growth over time with large amounts of shallow ecologically viable soil space controlled by tree roots.

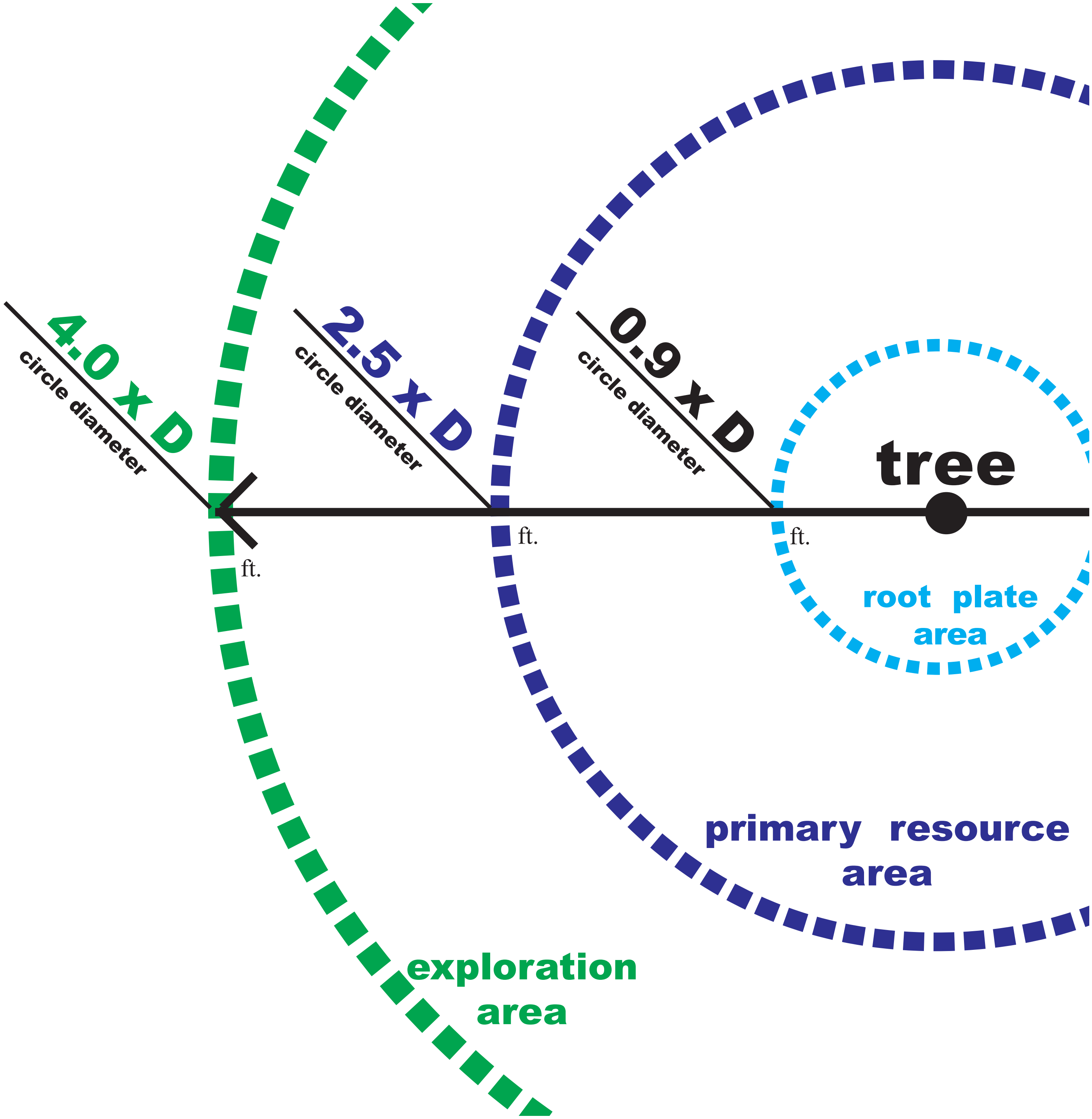


Figure 2: Definition of three functional tree rooting areas viewed from above. Tree stem diameter in inches (D) measured at 4.5 feet above the ground is used in determining specific tree rooting area diameters in feet.

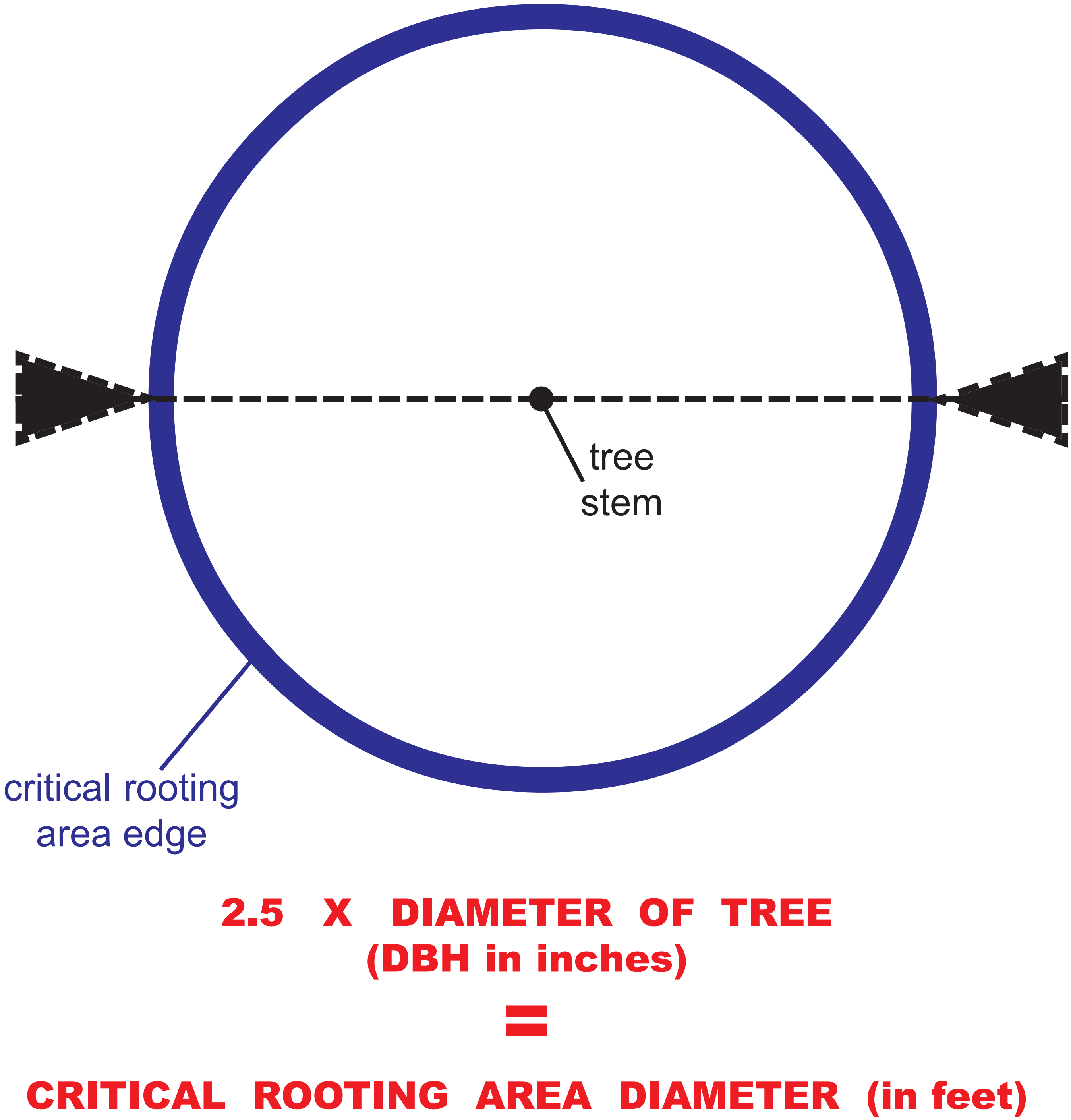


Figure 3: Estimate of the active critical rooting distance (a diameter in feet) for any tree.

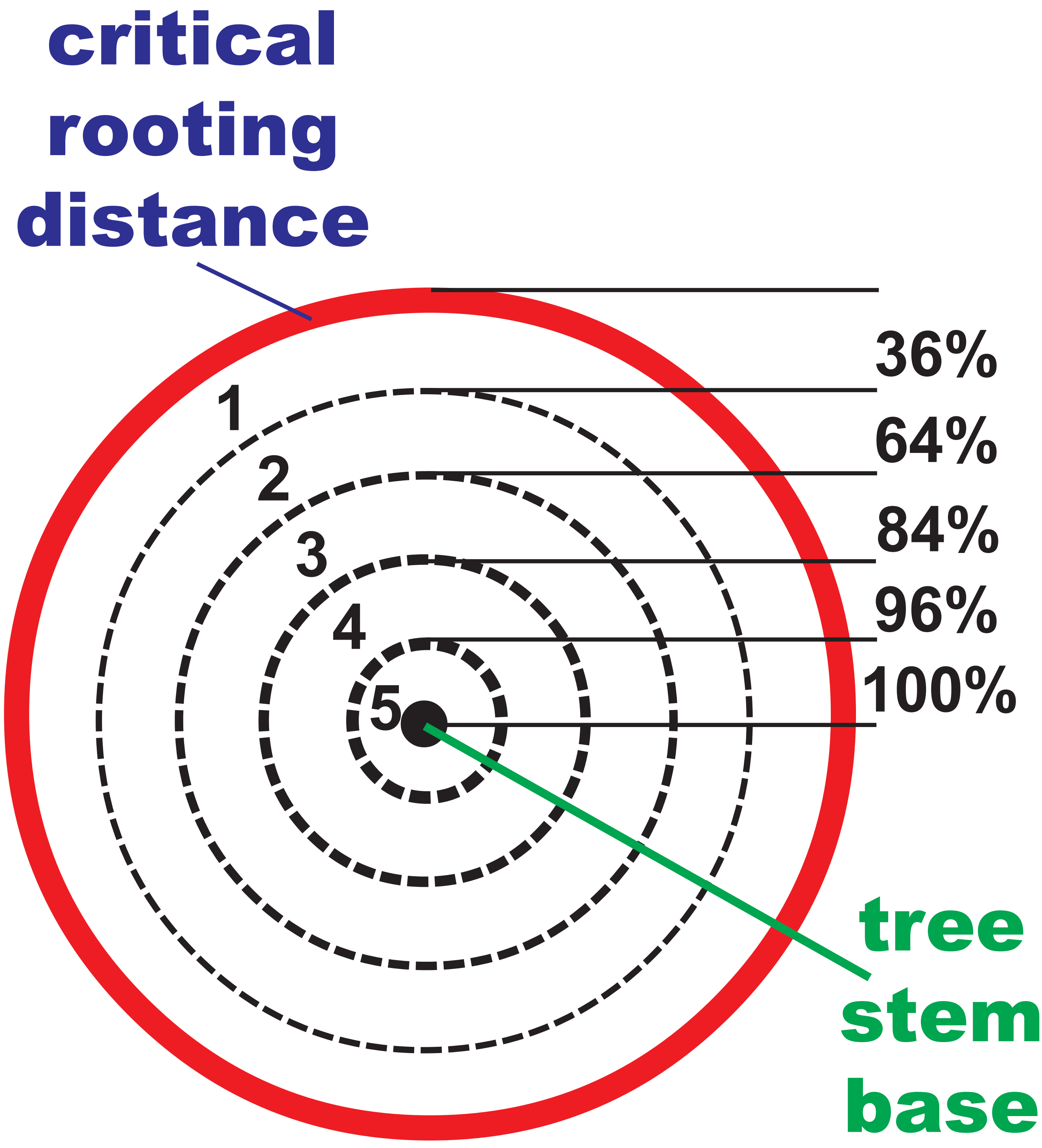


Figure 4: Percent of active tree rooting area disrupted when soil and roots are damaged around a tree, divided into 1/5s. The outer limit is the critical rooting distance.
(2.5 X tree diameter in inches = critical rooting distance in feet)

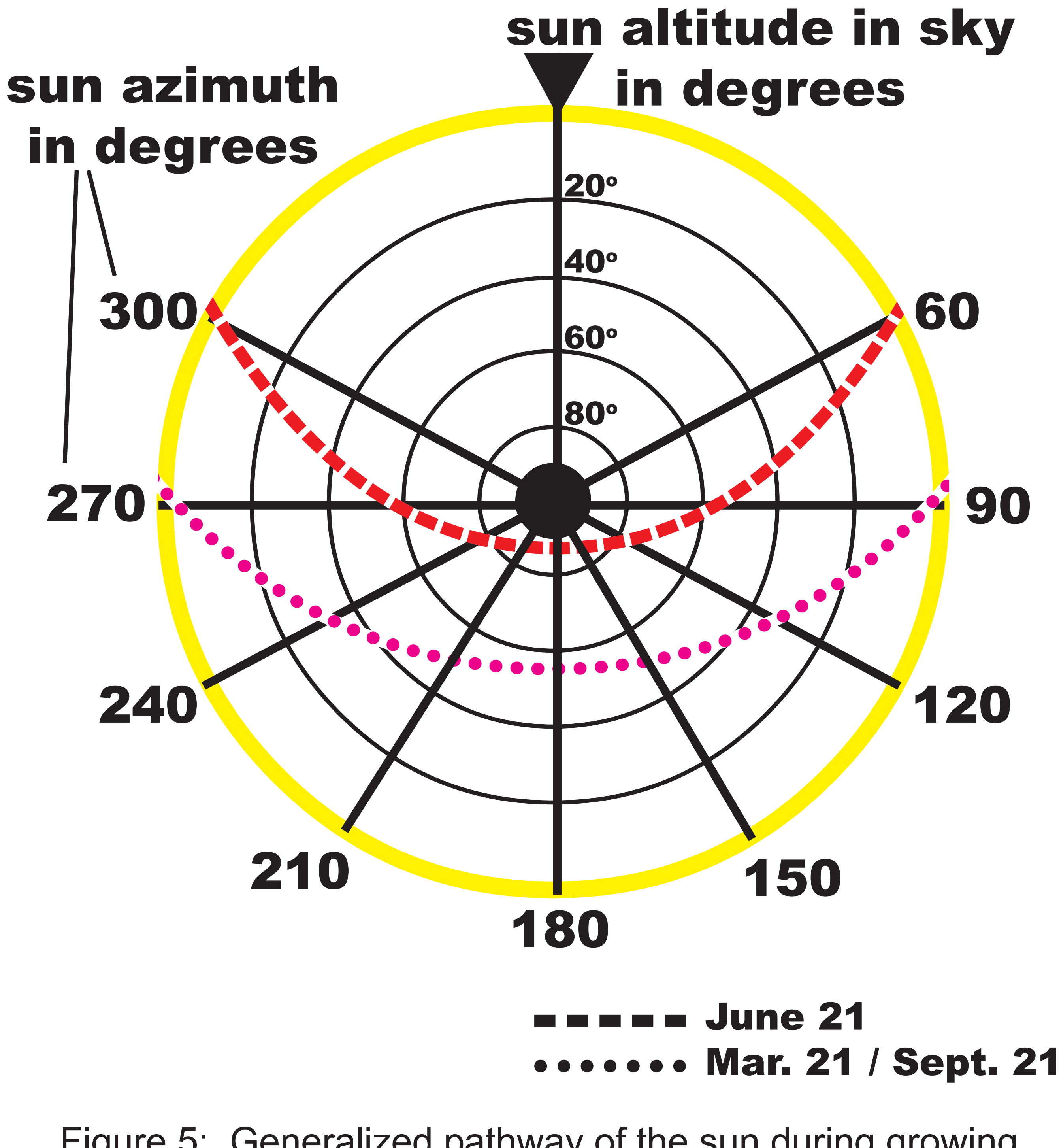


Figure 5: Generalized pathway of the sun during growing season (between the two dotted lines). The shade field is the opposite side of tree / building from sun.
(this example for Atlanta, GA)

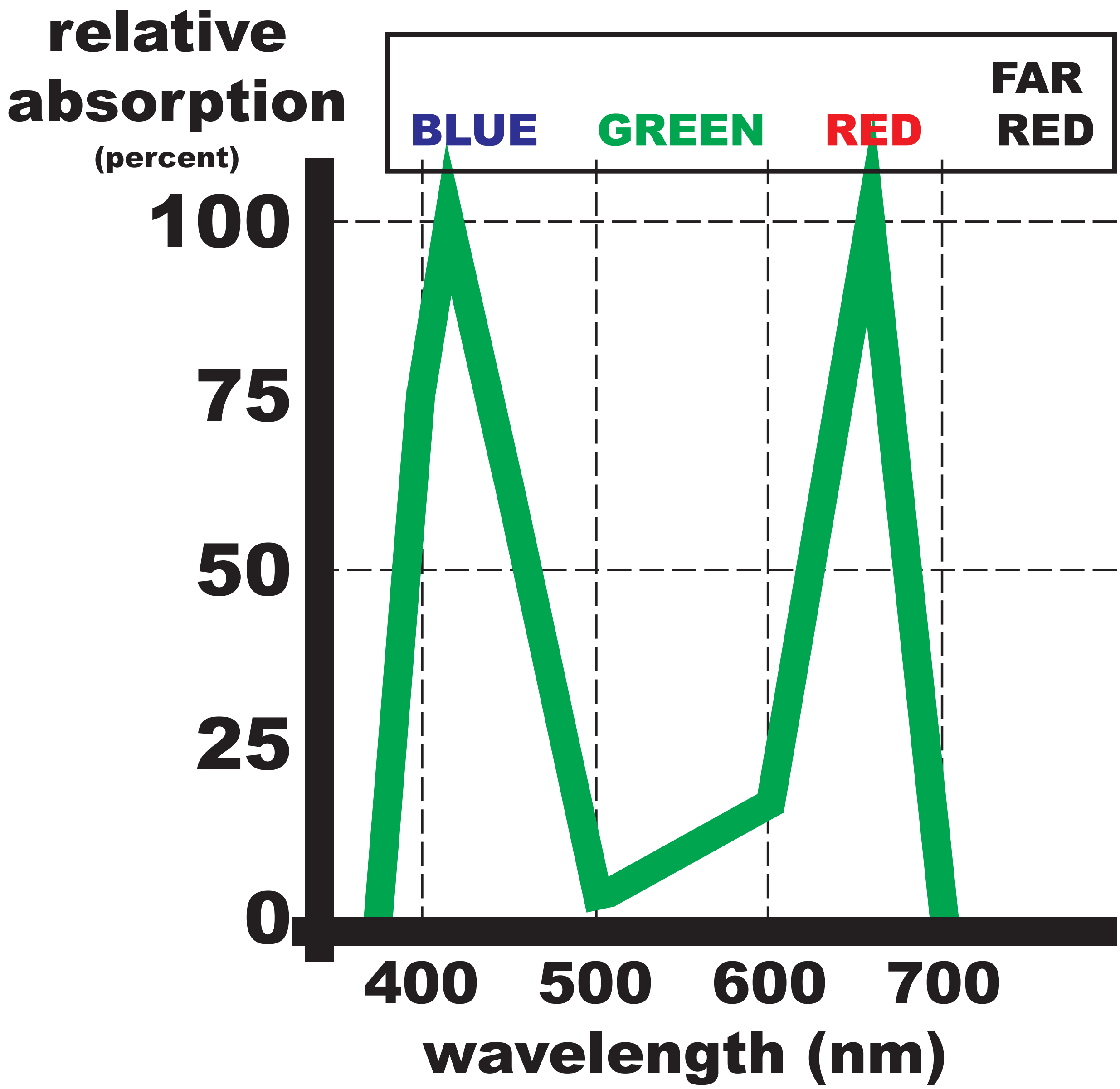


Figure 6: Simplified view of light wavelength (nm) absorbance and color area used by chlorophyll.

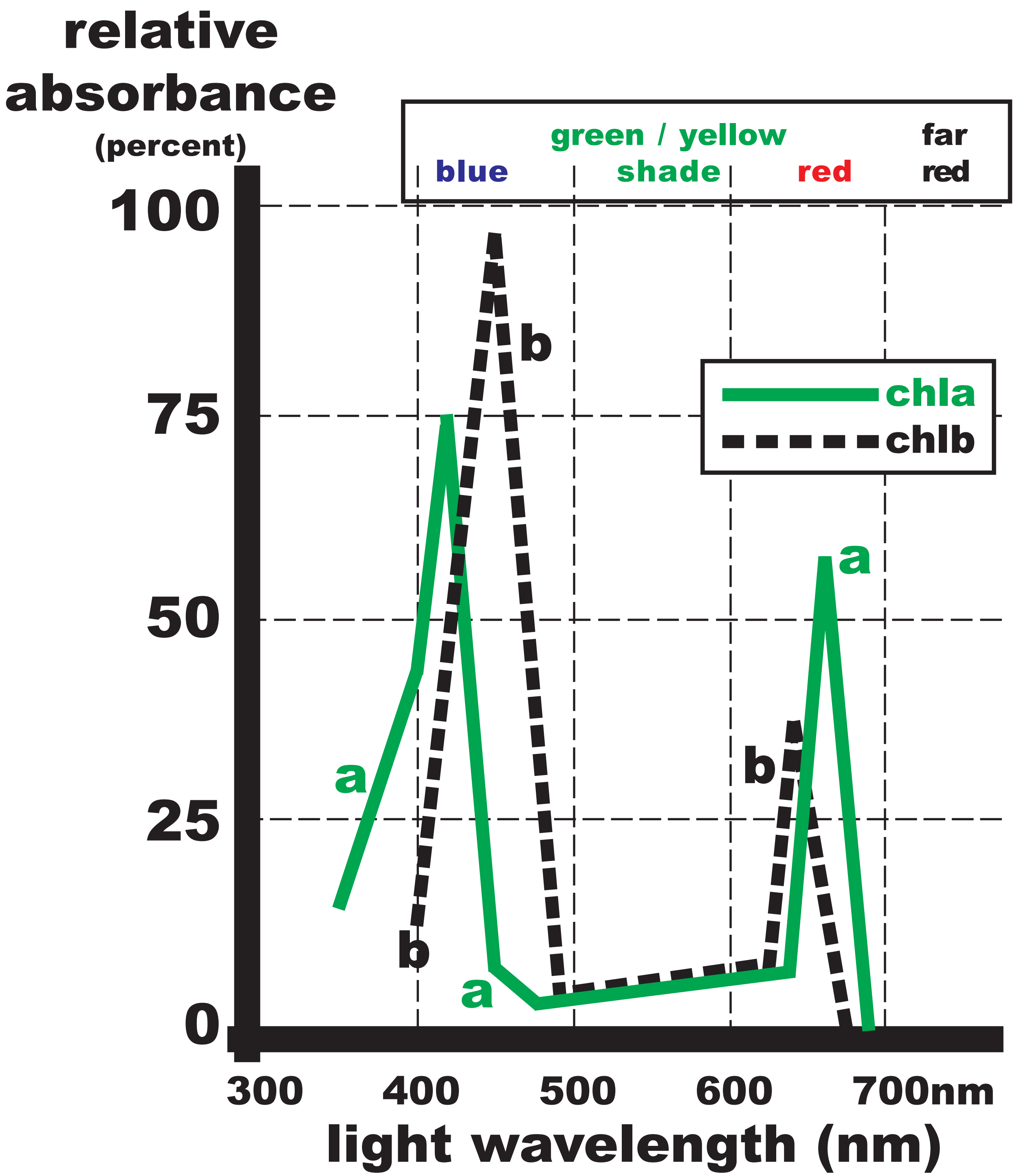


Figure 7: Relative absorbance values for chlorophyll a (chla = full sun pigment), and for chlorophyll b (chlb = shade pigment). General light color descriptors for wavelengths are given.

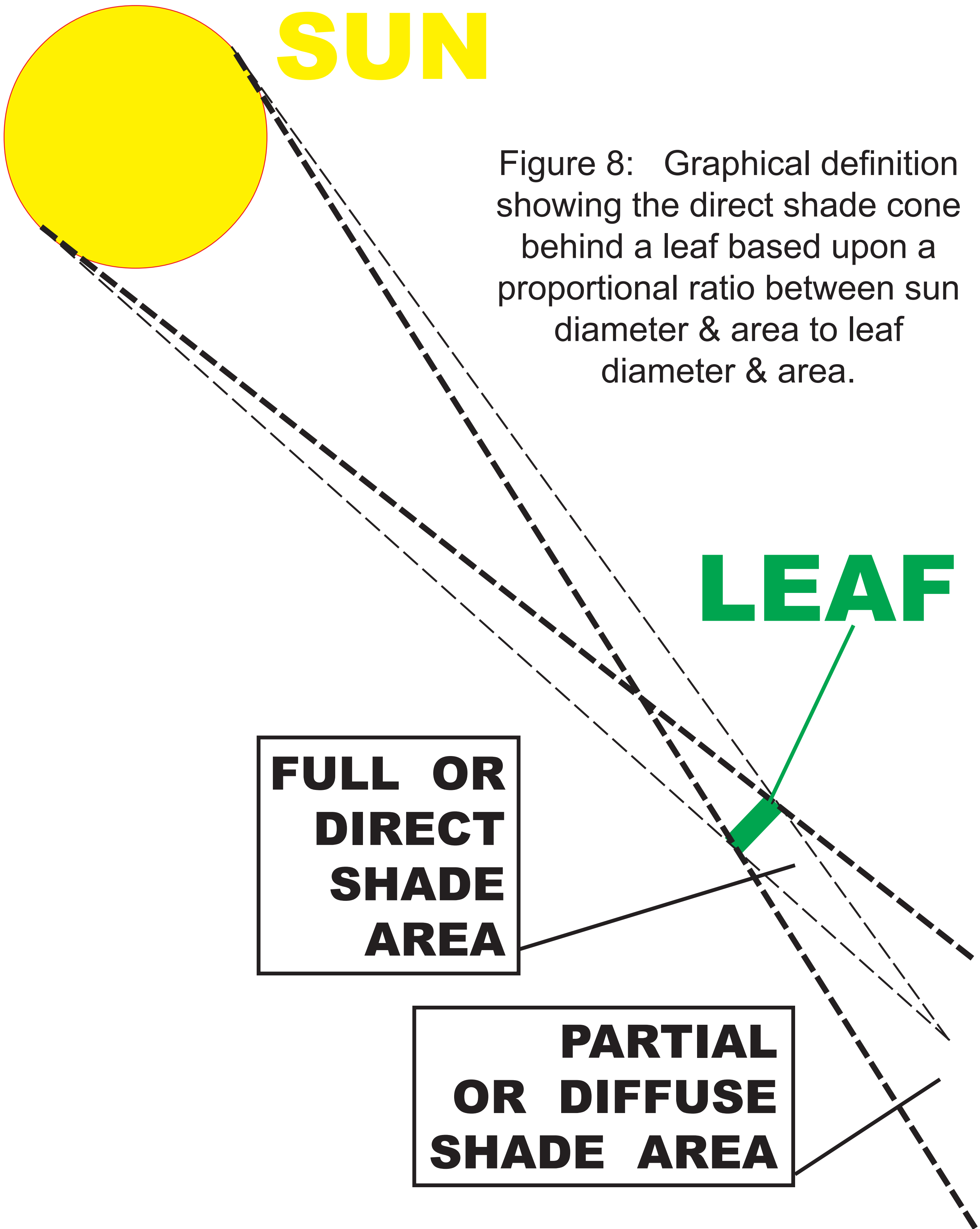


Figure 8: Graphical definition showing the direct shade cone behind a leaf based upon a proportional ratio between sun diameter & area to leaf diameter & area.

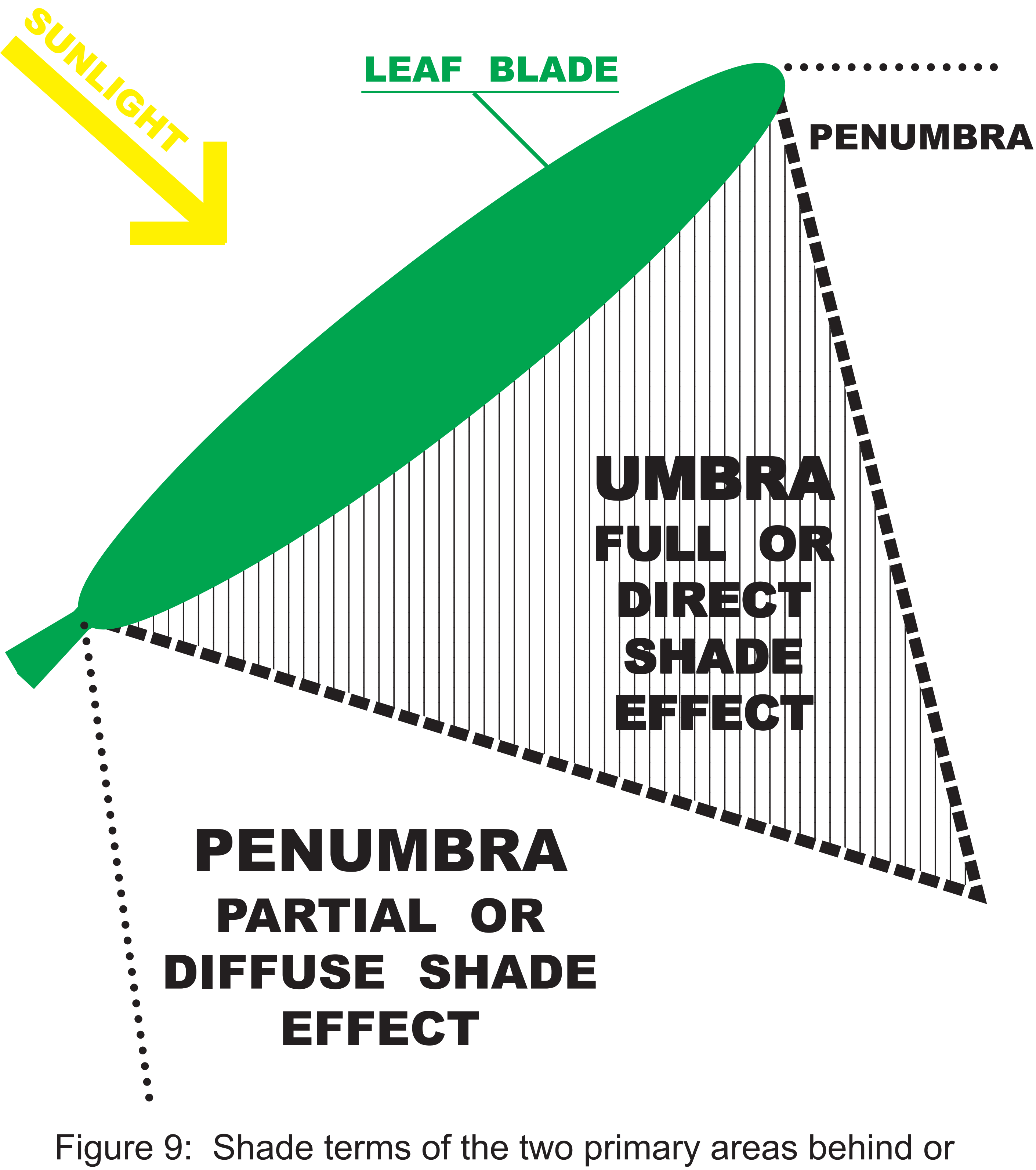
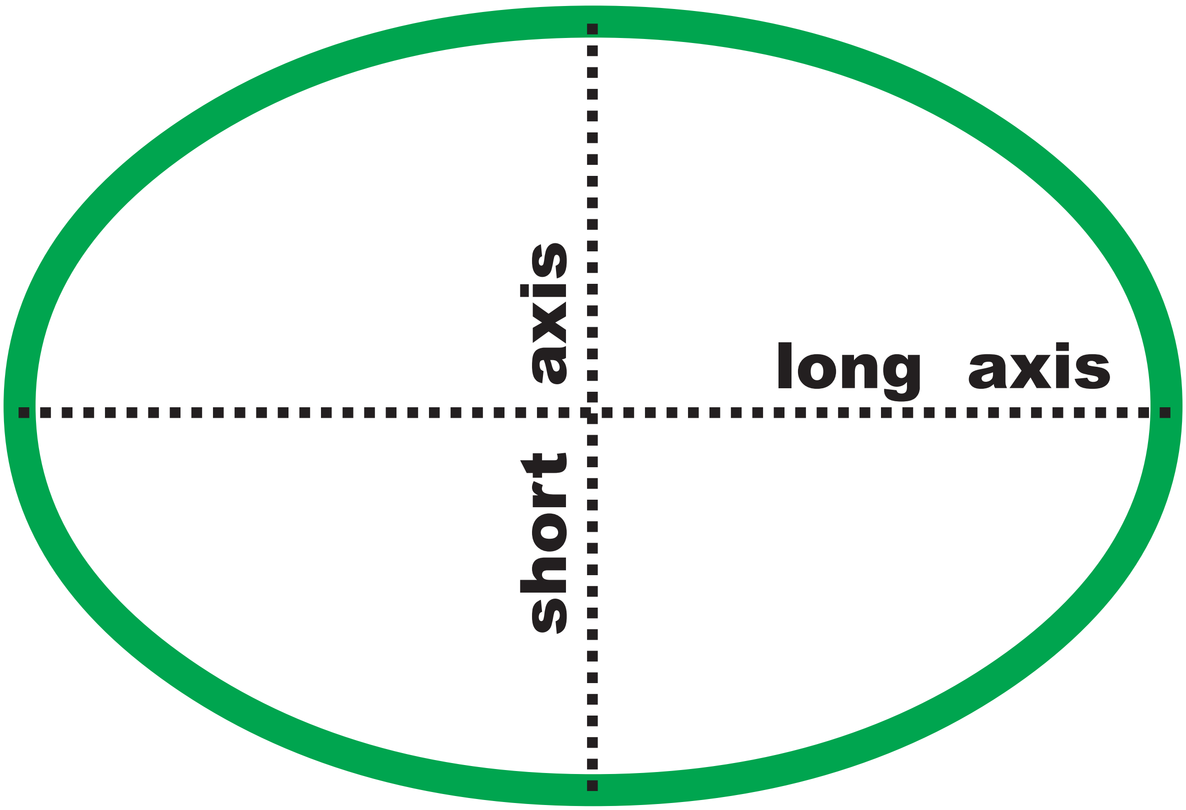


Figure 9: Shade terms of the two primary areas behind or below a leaf opposite incoming sunlight shown in two dimensions.

ellipse scribed completely within leaf outline



(long axis distance in inches + short axis distance in inches) / 2 =

effective leaf diameter or ELD

Figure 10: Graphical representation of how effective leaf diameter is determined. ELD is an average length of the long and short axis for the largest ellipse scribed inside a leaf outline without crossing a leaf edge.

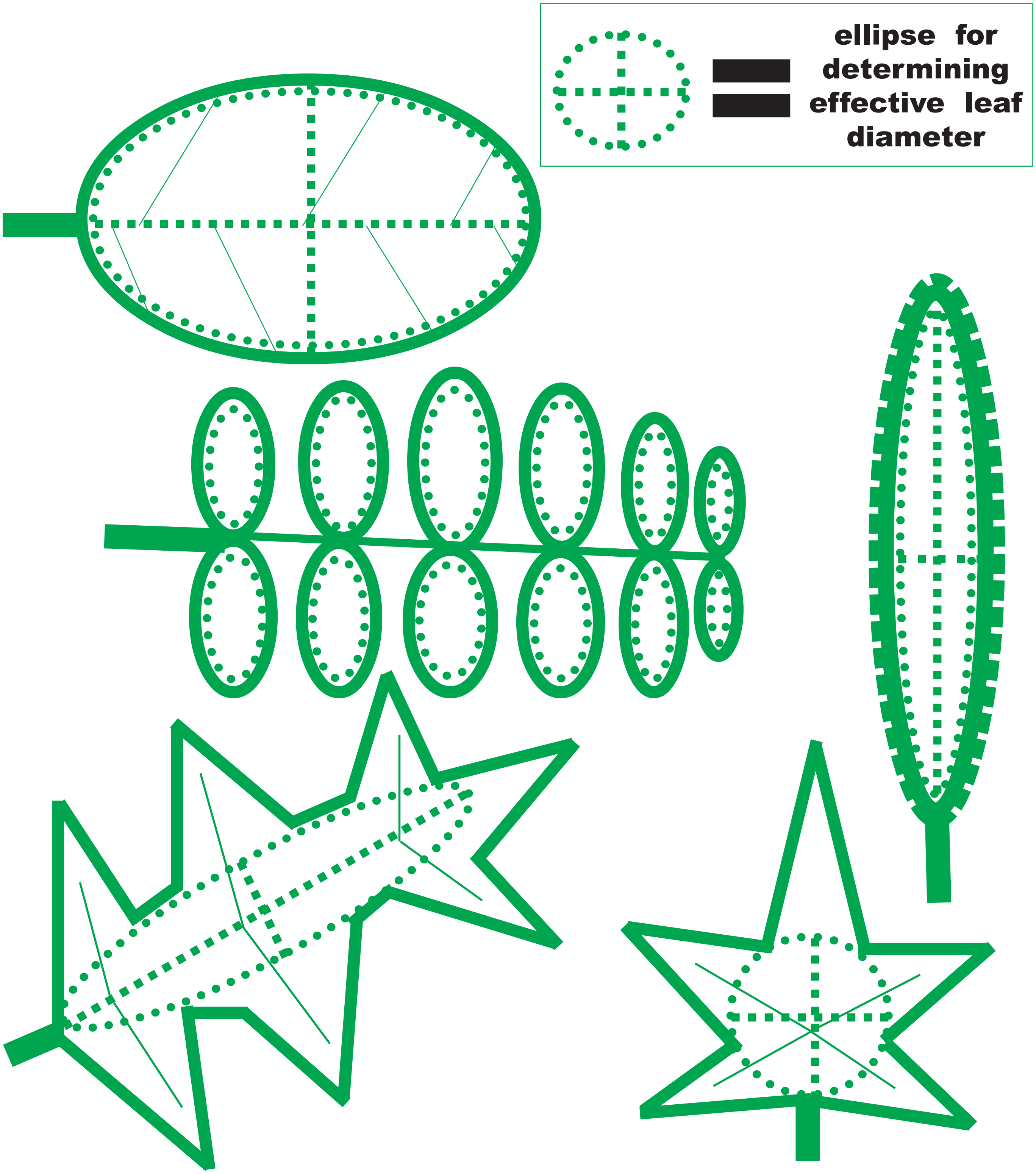


Figure 11: Graphical definition of effective leaf diameters (ELD)

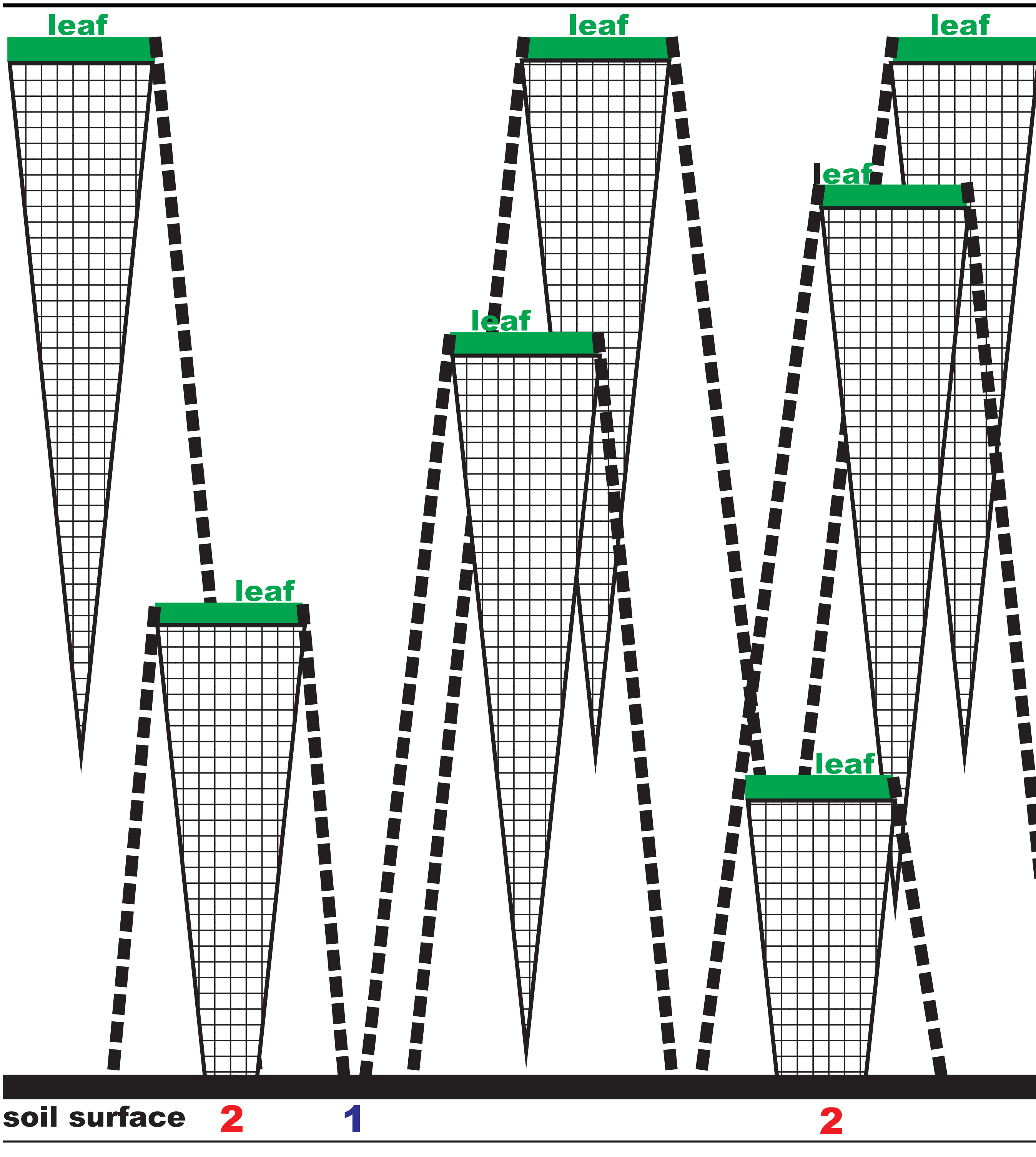


Figure 12: Additive effects of several leaf layers upon direct and diffuse shade at one moment in time. In only one spot (#1) does full sunlight strike the soil surface. In two places (#2) a direct shade effect is present at ground level. The rest of the soil surface is covered with diffuse shade.

Table 1: Example shade components for select tree species.

Effective leaf diameter (ELD) in inches is the average length of the long and short axis of the largest ellipse which can be circumscribed over a leaf surface which does not cross a leaf edge. Direct shade effect distance (DSED) in feet is the length of the umbra behind or below a leaf.

species	effective leaf diameter (inches)	direct shade effect distance (feet)
black gum	3.5	17.5
black locust	.75	4.0
catalpa	6.0	30.0
cherries	2.0	10.0
holly	1.5	7.5
honeylocust	.5	2.5
large-leaf elms	3.5	17.5
lobed oaks	1.5	7.5
magnolia	5.0	25.0
pines	.25	1.5
red maple	2.5	12.5
river birch	2.5	12.5
sugar maple	3.0	15.0
sweetgum	2.0	10.0
unlobed oaks	3.0	15.0
willows	1.5	7.5
yellow poplar	3.5	17.5

[direct shade effect distance in feet = ((effective leaf diameter in inches) X 60) / 12]

Table 2: Calculated value of direct shade effect distance (DSED) in feet for a number of effective leaf diameters (ELD) measured in inches.

ELD in.	DSED ft.	ELD in.	DSED ft.
0.25	1.3	5.5	27.5
0.5	2.5	6.0	30
0.75	3.8	6.5	32.5
1.0	5	7.0	35
1.5	7.5	7.5	37.5
2.0	10	8.0	40
2.5	12.5	8.5	42.5
3.0	15	9.0	45
3.5	17.5	9.5	47.5
4.0	20	10.0	50
4.5	22.5	10.5	52.5
5.0	25	11.0	55

DSED ft.= ((ELD in.) X 60) /12.

Table 3: Calculated minimum mulching distance (radius in feet) away from a tree stem based upon tree diameter in inches measured at 4.5 feet above the ground.

tree diameter (inches)	mulching radius (feet)	tree diameter (inches)	mulching radius (feet)
1	5	32	20
2	5	34	21
3	6	36	22
4	6	38	23
5	7	40	24
6	7	42	25
7	8	44	26
8	8	46	27
9	9	48	28
10	9	50	29
11	10	52	30
12	10	54	31
13	11	56	32
14	11	58	33
15	12	60	34
16	12	65	37
17	13	70	39
18	13	80	44
19	14	85	47
20	14	90	49
22	15	95	52
24	16	100	54
26	17		
28	18		
30	19		

[4 + (0.5 X (tree diameter in inches)) = mulch island radius in feet]

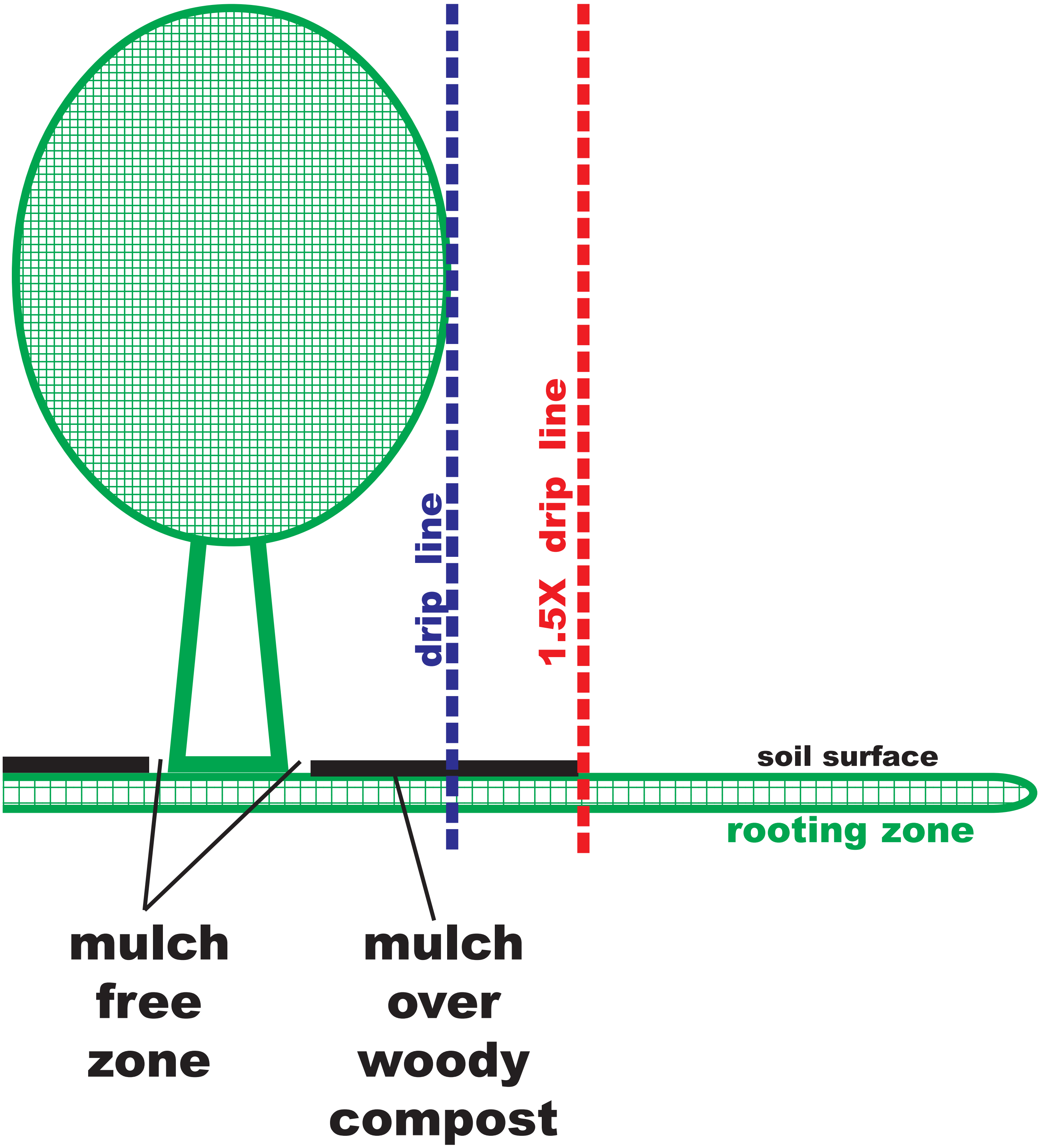


Figure 13: Side view of tree in soil with 1-2 inches of mulch over 1/2 inch woody compost placed on soil surface out to 1.5 times the drip line. Note mulch and compost are not placed against base of tree outward for 4-6 inches.

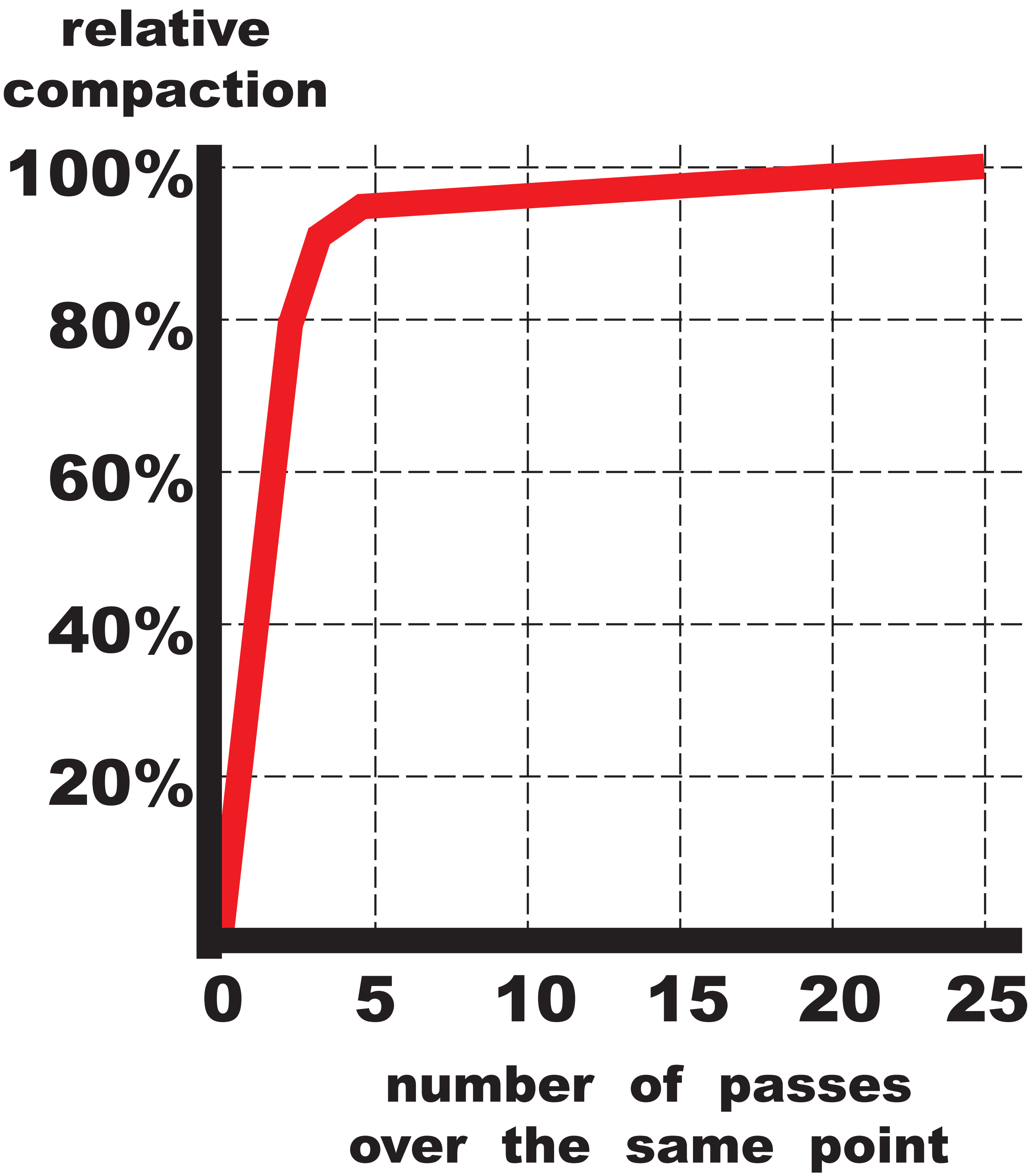


Figure 14: Number of passes over the same point with equipment, vehicles, or foot traffic needed to compact moist soil.

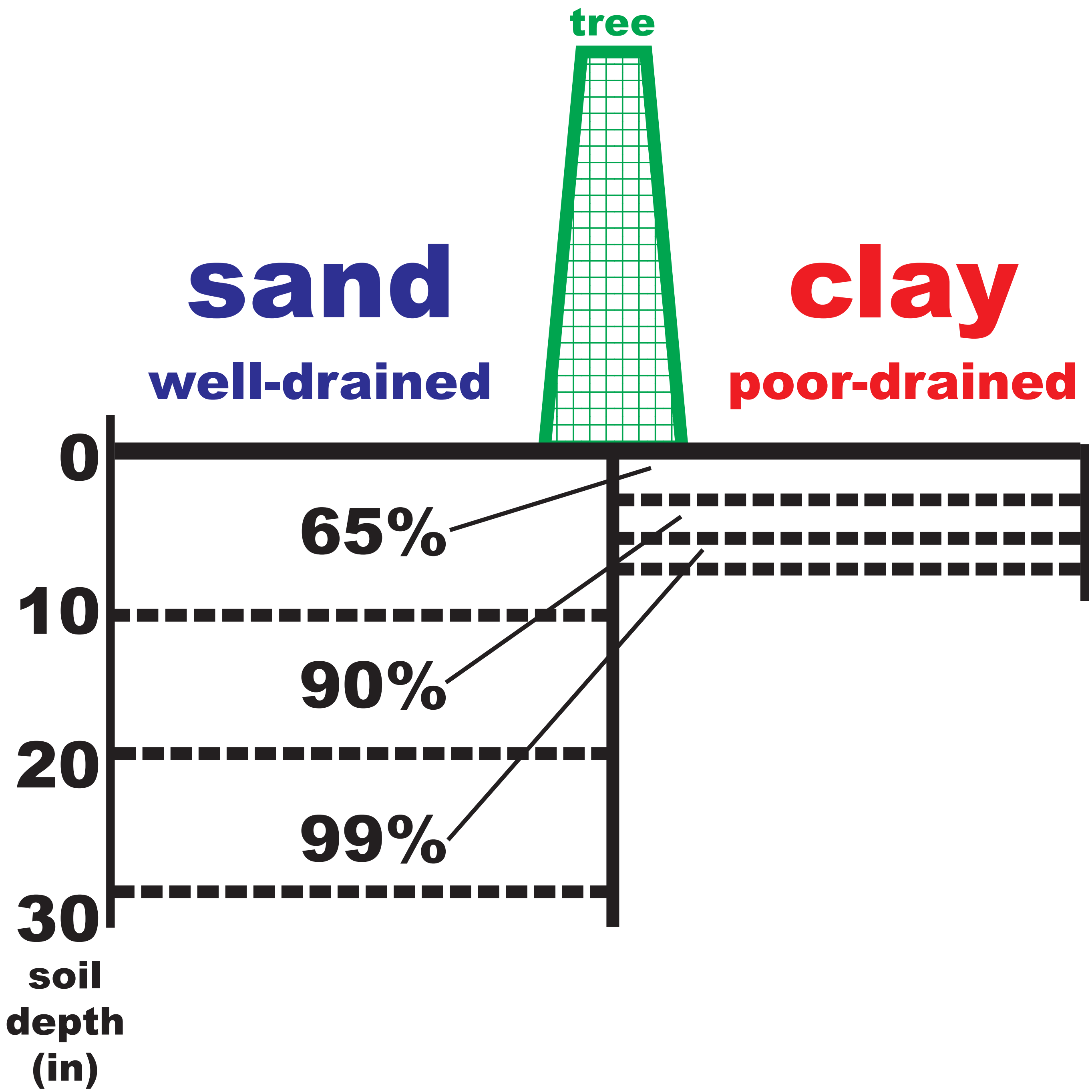


Figure 15: Percent of tree's active absorbing root system growing at deph (in inches) for different texture / drainage class soils.

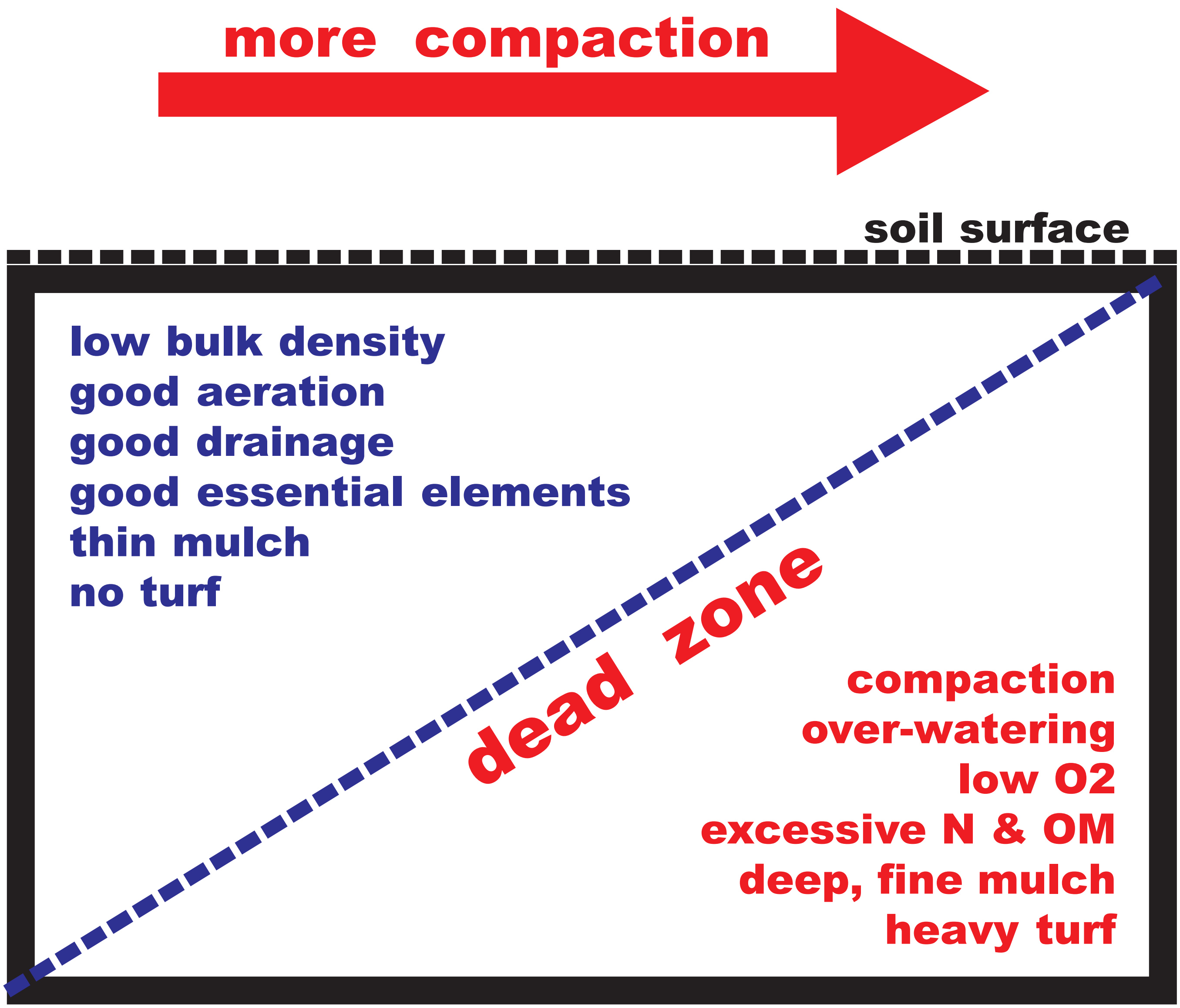


Figure 16: Two-dimension representation of the anaerobic zone (dead zone) at some soil depth moving closer to the surface with changing resources and mis-management.

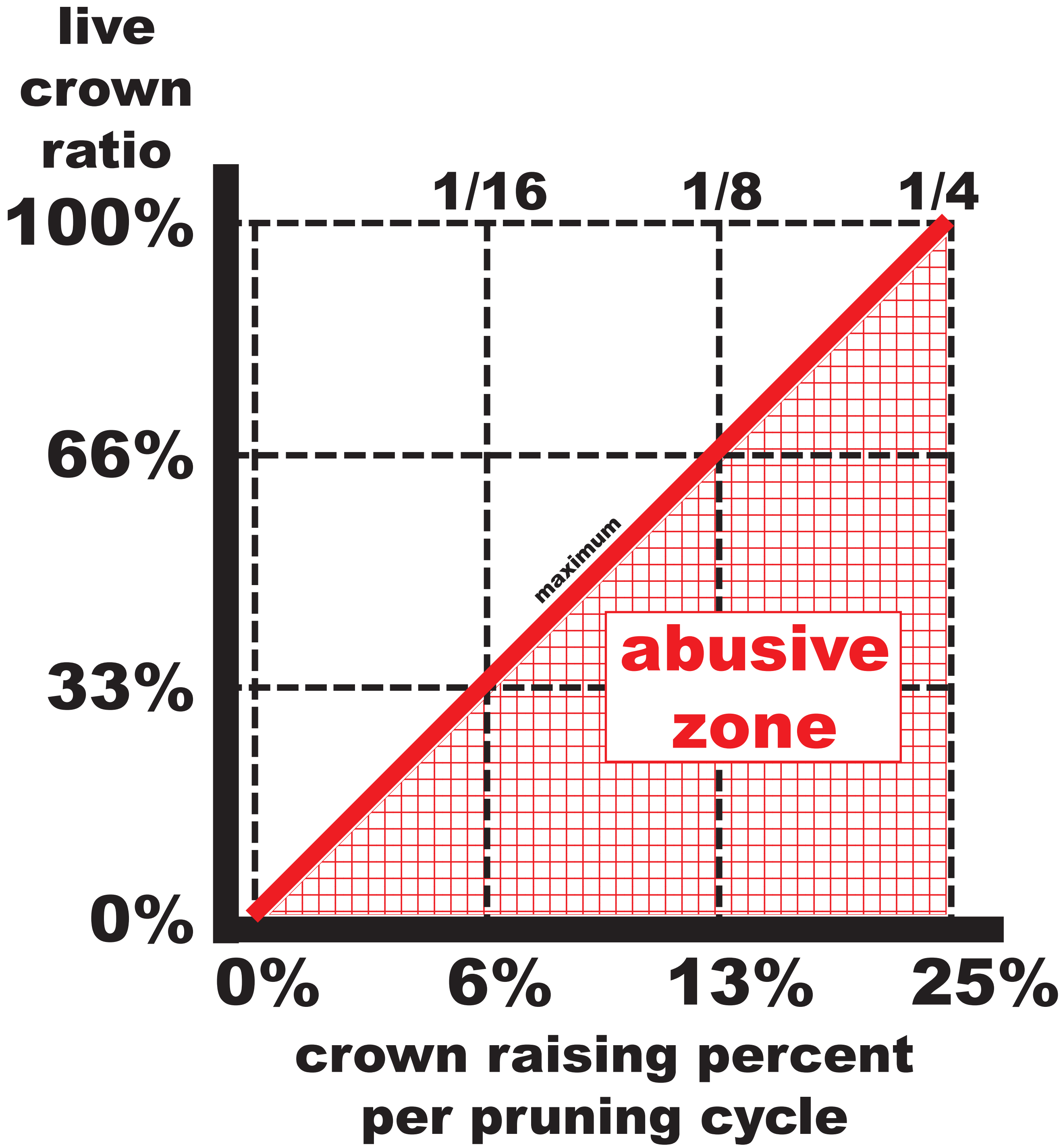


Figure 17: Coder crown raising dose assessment per pruning cycle demonstrating potential abuse. Graph is the percent of live crown (height basis) that can be removed, if warranted, every pruning cycle (not less than every three years) in a crown raising process.

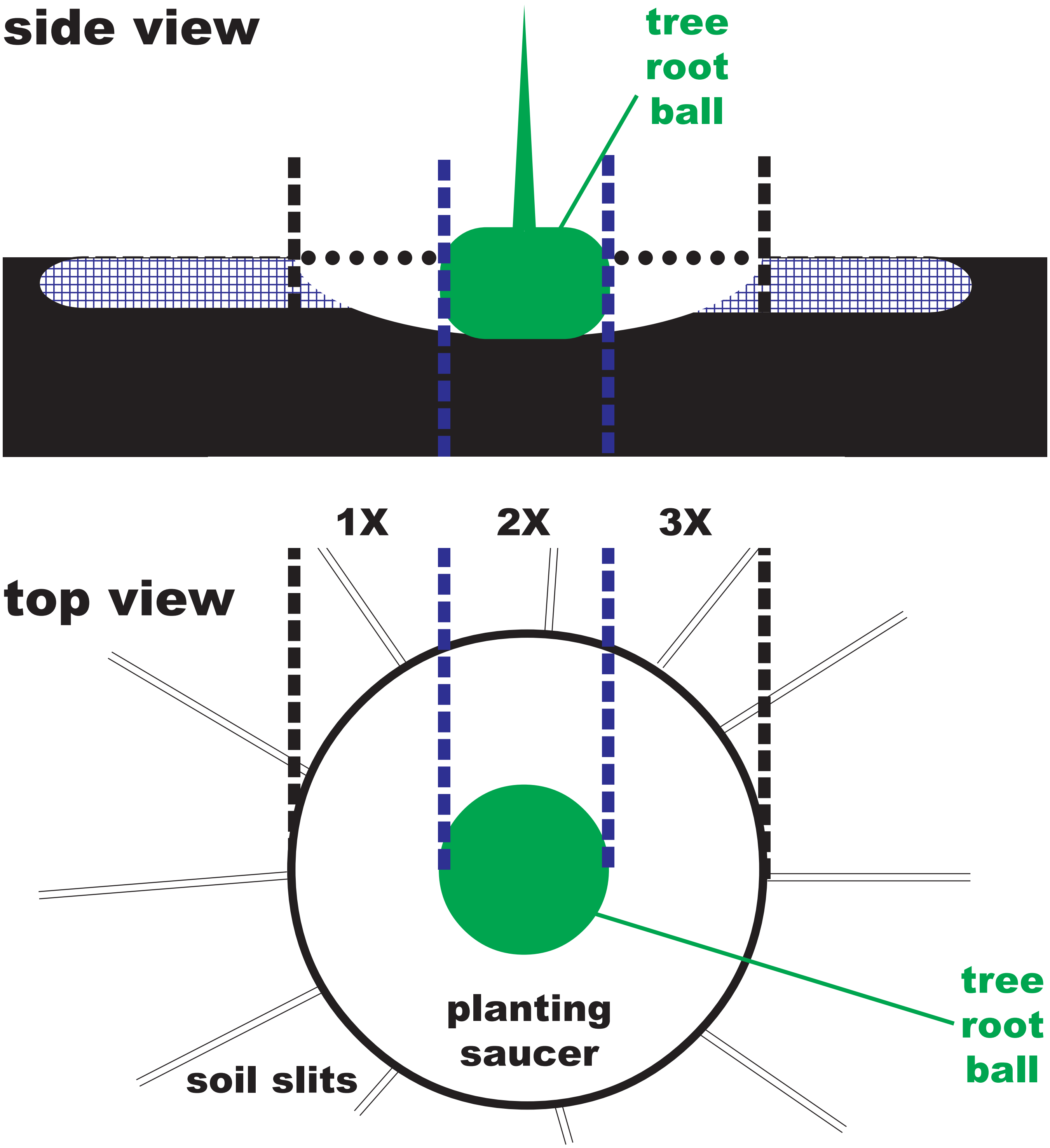


Figure 18: Side view and top view of planting saucer (3X root ball diameter) and radial slices / slits dug away from the saucer into native soil. Note tree planted high in saucer.

1. Selective pruning -- crown raising and thinning;
2. Raise mower height;
3. Reduce traffic on tree / turf areas to minimize compaction and turf wear, or alternatively plan for fall sodding;

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4. Reduce irrigation levels – err on under-watering rather than over-watering;
5. Deep water occasionally rather than shallow water often;
6. Cut turf nitrogen fertilization by at least 50% in shade areas (~3/4 pds N per 1,000 ft^2 or less);

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7. Use generous mulch islands, or perennial shrub or non-vining ground covers in shade areas;
8. Select turf species / cultivars carefully for shade and cold tolerance, and disease resistance, (consider turf mixtures);
9. Rake turf surfaces often especially in Fall to remove tree litter as soon as possible;

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10. Assure soil drainage, and reduce or prevent compaction;
11. Do not inhibit air flow across turf surface with hedges, walls, berms, or dense plantings;
12. Zone pesticide treatments separately for trees and turf, and monitor shaded areas closely. Be ready with fungicides to maintain turf performance;

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13. Develop realistic expectations of tree and turf performance among clients – both trees and turf will have performance impeded by growing together. Segregation of plant types with targeted management by plant type will bring success.

Figure 19: Check-list for tree / turf management in landscapes.