Green Industry Web Portal

Landscape Management Certification Program

Presented by Auburn University at Montgomery, the Appalachian Regional Commission, the Green Industry Associations and the Green Industry Web Portal

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Note: this guide is meant to be support to help prepare you for the **Landscape Management Certification Exam** offered by the Green Industry Web Portal, www.giwportal.org, and partnering agencies.

Although this guide has been reviewed, in part, over several years by state regulatory staff, industry educators and licensed and degreed horticulturists, please highlight any areas of concern so they can be addressed during the training.

The Green Industry Web Portal is meant to be a partnership between all the schools, corporations, industry and governmental agencies to improve Green Industry education in the United States.

We gratefully acknowledge the permission to use images and content in this guide from many industry educational and corporate sources. As with all public educational materials, please do not sell any content to students or industry members. Access to GIW Portal power points, video and other materials are always available at no-cost to the user.

Many of the linked publications that follow are for reference and further learning for you and your students. You are not expected to learn all the information referenced in the guide.

If you are a high school Ag teacher, most of the information is meant to be a simple review. If you are a company owner or Human Resource professional, you should know the content is frequently updated and reflects modern Best Management Practices for landscape and turf.

Warning – before applying any pesticides or using equipment, the owner's manual and pesticide labels must be thoroughly read and understood!

Intro to the LM Certification Study Guide and Support Materials

This study guide is designed to help support your efforts to prepare for the Green Industry Web Portal's **Landscape Management Certification Exam**.

The certification is meant to be an entry-level credential and is currently being awarded to landscape professionals, high school Agriculture teachers and students in the United States. Many industry employers are using the certification as part of their career ladder resulting in raises and promotions for certified employees.

Our hope is you will continue in your pursuit of industry professionalism and add state pesticide and landscape contracting licenses and additional GIW Portal certifications such as Urban Forestry, Turfgrass Management, etc. and those offered by the International Society of Arborists, the Professional Grounds Management Society, and others.

In addition to this guide, we will reference and give you links to Cooperative Extension System publications on pruning, turf care, planting, etc. The Green Industry Web Portal, www.giwportal.org, and these guides feature links to existing support materials and new video clips and PowerPoint presentations.

Horticulture is an art and a science, and recommendations vary due to soil types, climatic zones and plant species. The exam committee has attempted to eliminate "trick" questions or test items that are controversial. Please let us know if you find poorly written or confusing content in this guide or on the exam.

If there are concepts in this guide that differ slightly with the referenced extension bulletins, please "go with the guide" for best exam results. Some of the following information may be considered simplistic, but the idea is to improve your practical knowledge and your results in the field.

If you need more help, Green Industry Web classes will be offered free of charge or low-cost throughout the year for students, teachers, and industry professionals across the southeast. You may also want to visit your local Cooperative Extension System office and speak with your county agricultural agent and search their sites for additional resources.

There are other great websites, such as “Horticulture on the Internet” and “EAnswers”, or just go to your Internet search engine, type in the plant name or term and select “enter.” An excellent, and very large, ACES publication is Alabama Smart Yards, available at http://www.aces.edu/pubs/docs/A/ANR1359/ANR1359.pdf .

Overview

The student preparing to take the Landscape Management Certification exam must be able to:

1. List or pick out the major functions of plant nutrients.

2. Describe or identify basic plant physiology.

3. Identify and describe soil science concepts.

4. Identify and describe basic plant anatomy.

5. Select the proper time of the year and the proper method for pruning various trees and shrubs. Please refer to the following publications on pruning for help in this area: http://www.aces.edu/pubs/docs/A/ANR0258/ANR0258.pdf

   Virginia Pruning Calendar: https://pubs.ext.vt.edu/430/430462/430462_pdf.pdf

6. Describe or identify common pruning methods or terms.

7. Identify or describe proper staking and guying methods.

8. Select the proper method of planting for different plant forms, including bare root, container, and ball and burlap.

9. Select or identify major turf management concepts.

10. You will be asked to identify samples of plants commonly used in the United States by image or sample.

11. You will be asked demonstrate a *very basic* understanding of integrated pest management or IPM.

12. Select or identify proper weed management concepts with mulches and preemergent herbicides.

13. Identify basic business concepts.

14. Select the proper answers to horticultural math problems.

15. Select the proper answer to basic landscape safety questions.

Nutrients

Plants require **16** elements found in nature to properly grow and develop. The elements carbon, hydrogen, and oxygen are needed in the greatest volume and are supplied by carbon dioxide, air, and water found in the atmosphere. Nutrients derived from the soil and fertilizer include:

- **Primary macronutrients** – the plant nutrients nitrogen, phosphorous, and potassium; applied normally in greater pounds per acre for most crops.

The percentage of each is expressed as the analysis or grade on the label in the order nitrogen (N), phosphorous (P), or potassium (K).

- **Secondary macronutrients** – the plant nutrients calcium, magnesium, and sulfur; applied normally in lesser pounds per acre than the primary macronutrients.

- **Micronutrients** – nutrients applied in very small amounts to plants; some as little as a few ounces per acre.

The most important nutrient to plant growth is the one that is in short supply. This concept of the "limiting nutrient" is important to remember as you make applications without soil testing.

ACES Fertilizer and Lime publication – http://www.aces.edu/pubs/docs/A/ANR0388/ANR0388.pdf

- They are divided into three categories as follows:

Atmospheric	Macronutrients	Micronutrients
C Carbon	N Nitrogen	Fe Iron
H Hydrogen	P Phosphorus	B Boron
O Oxygen	K Potassium	Z Zinc
	Ca Calcium	Cu Copper
	Mg Magnesium	Cl Chlorine
	S Sulfur	Mn Maganese
		Mo Molybdenum

- **Nitrogen** – the nutrient most responsible for green, vegetative growth and protein content in a plant

The overuse of nitrogen may lead to excess growth, disease, and insect problems. During cool weather, it is important to use nitrate forms of nitrogen instead of ammonium to encourage growth in pansies and other flower displays.

Nitrogen is usually lost to the air or groundwater quickly, leading to pollution problems if misapplied. Nitrogen is considered a primary macronutrient.

- **Phosphorous** – responsible for root growth, flowering and plant maturity

Phosphorous often builds up in the soil as it is not very mobile. Excess amounts may tie up micronutrients, such as iron, which may lead to poor growth in lawns, boxwoods, decorative container grown plants, etc.

Phosphorous is considered a primary macronutrient. In many areas of the US, phosphorous *can be considered a pollutant* and should not be applied unless indicated by a soil test. Many modern fertilizers will contain either no phosphorous or very small amounts.

- **Potassium** – is important to fight stress from cold, heat, drought, disease, etc.

Potassium is considered a primary macronutrient and is often applied as a "winterizer" although some research indicates it may be of little help as long as potassium is in adequate range.

- **Calcium** – is a secondary macronutrient responsible to help with proper cell division and is an important component of cell walls

Calcium is found in all limes and helps raise the pH of acid soils. Common types include calcitic and dolomitic lime. Excess applications of lime may lead to deficiencies of certain nutrients due to "mass action" and/or unavailability of iron and other metals due to high pH.

- **Magnesium** – is a secondary macronutrient and critical component of the chlorophyll molecule and its addition will green up plants and improve acidic soils

Magnesium sulfate, or Epsom salts, is an older-fashioned way to cause rapid green up but may damage sensitive plants due to its high salt content. The liming material that contains large amounts of magnesium and calcium is known as **dolomitic lime**.

- **Sulfur** – is a secondary macronutrient, important to protein synthesis in plants, and will help green up leaves, but will make soils more acidic if overused

Red oaks, camellias, azaleas, blueberries, centipedegrass, and other acid-loving plants often react well to sulfur applications. Sulfur may also be used as a pesticide to manage some insects, mites, and diseases, but can be very damaging to car finishes, copper downspouts, metal signs and markers, etc.

- **Iron** – is a micronutrient that allows rapid green up without much vegetative growth

Iron is common in most clay based soils, but may be unavailable due to pH and other soil issues. **Chelated iron** is a special formulation that allows plants to uptake iron even if the pH is very alkaline or basic.

- **Fertilizer Selection and Timing** — in most cases, a complete fertilizer, such as 16-4-8, 12-6-6, or 12-4-8, is generally recommended, unless the soil test reveals that phosphorus and potassium are adequate

- **Trees and Shrubs** — Trees and shrubs should be fertilized in early spring and a light fertilizer application can be made in early summer if temperature and moisture levels are conducive to plant growth

The **ANSI**, or American National Standards Institute, recommends that trees and shrubs be fertilized with 2 to 3 pounds of actual nitrogen per year, see below. For new plantings, 2 to 3 applications may be made during the growing season, although many landscape managers are now using once per year, slow-released products like Spread It and Forget It. Mature plantings that have good color and growth, little or no fertilizer should be applied. Avoid fertilizing trees and shrubs stressed by drought during the summer months. If water is unavailable, do not fertilize at all because plants will be unable to absorb the nutrients. In dry weather, the fertilizer may cause water to leave the roots due a process known as **plasmolysis**.

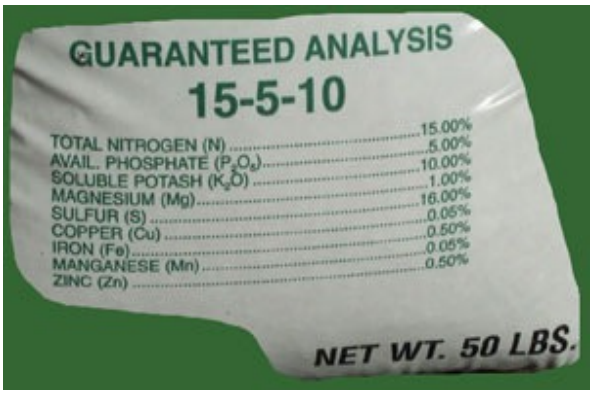
For shrubs and trees in lawns, apply the fertilizer at the appropriate time and rate for the turfgrass. Always be sure that adequate moisture (supplied by either rainfall or irrigation) is

available. Fertilizing cool season turf in September may encourage growth in nearby trees and shrubs leading to winter kill of succulent tissue.

- **Perennials** — flowering perennials may benefit from a single fertilizer application just before, or at, the time that new spring growth is pushing up

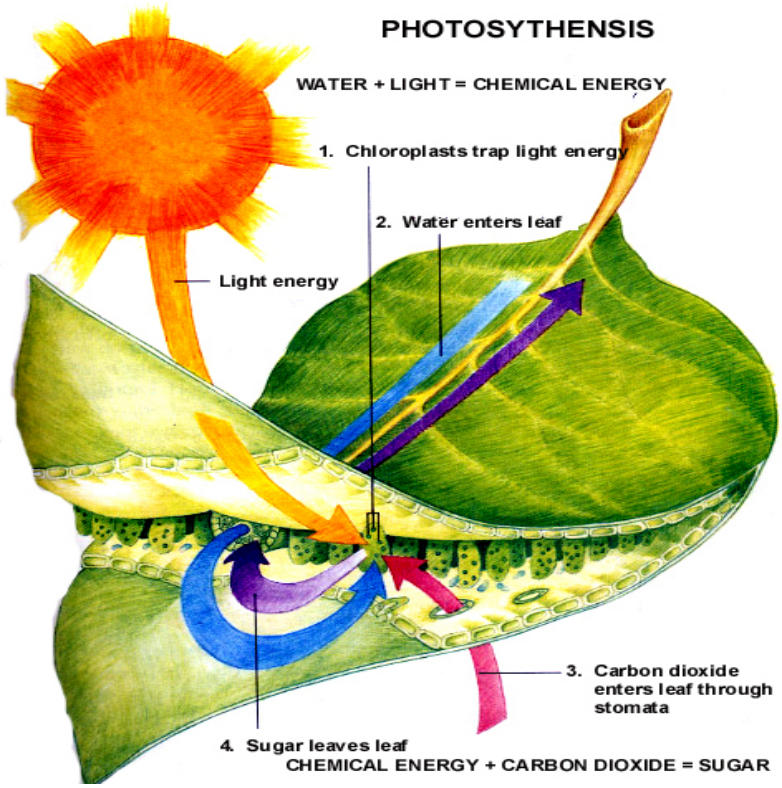
- **Actual Nitrogen** — the term used to designate the percentage of nitrogen in a fertilizer to help indicate how much carrier to use for a desired application

For example, a fertilizer with an analysis of 2005 has 20% actual nitrogen. If your specifications call for 1 pound "actual" per thousand square feet, you would apply 5 pounds of that fertilizer. (0.20 x 5 = 1.00)



Plant Physiology Basics

- **Photosynthesis** – the food-making process in plants where water vapor and oxygen are released through the leaves to allow uptake of carbon dioxide and the formation of sugars



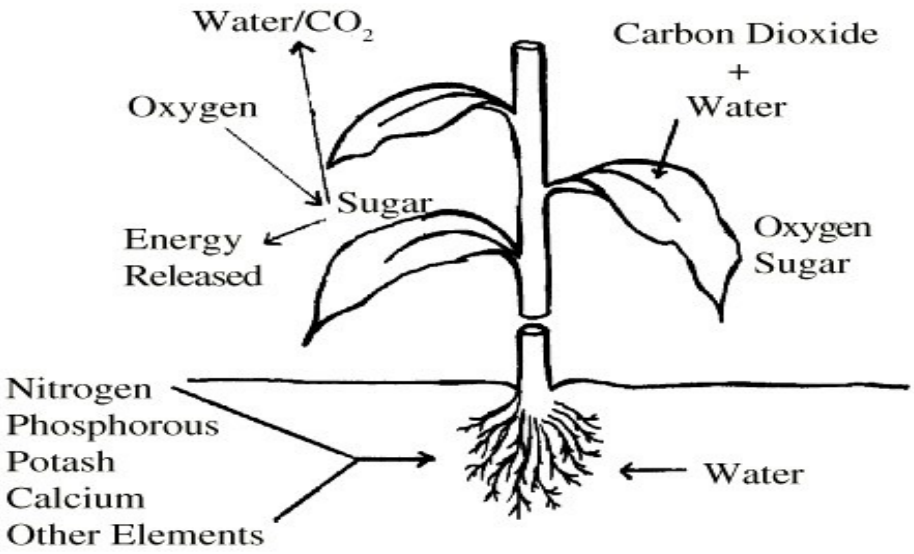
Courtesy, Butler University Herbarium

Sunlight and the pigment chlorophyll are necessary to the process. All green parts of the plants photosynthesize. Remember that applying herbicides around root flares and trunks may damage trees.

Removing too much leaf surface from a tree, shrub, or lawn through pruning or mowing slows photosynthesis and food storage, making plants more susceptible to insects and diseases.

How a Plant Grows

Respiration ***Photosynthesis***



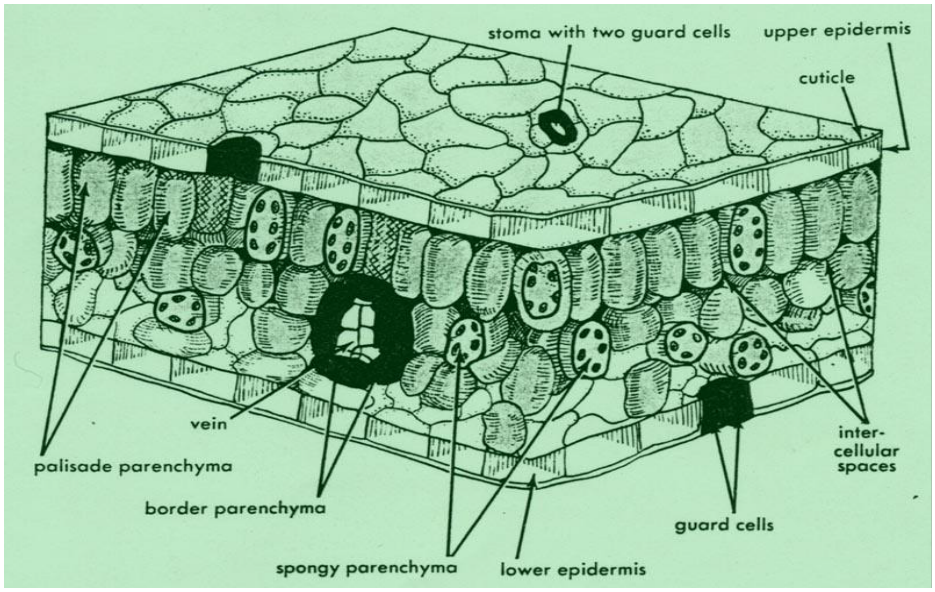
http://ag.arizona.edu/pubs/garden/mg/botany/physiology.html

- **Respiration** – is the breakdown of stored food in the plant

Stored sugars are broken down in an efficient, orderly way to fuel the work of the plant. Soils that are very wet due to over-irrigation or rain in the summer may lead to plant death as the plants cannot respire. Professionals in areas of the US that have poorly drained clay soils frequently encounter this situation.

Remember, "roots grow where the air and water flows." *No soil air equals dead roots and weak plants!*

- **Transpiration** – the process by which water moves into the roots, up the trunk, and out of the leaf stomata as water vapor



Cross section of typical plant leaf.

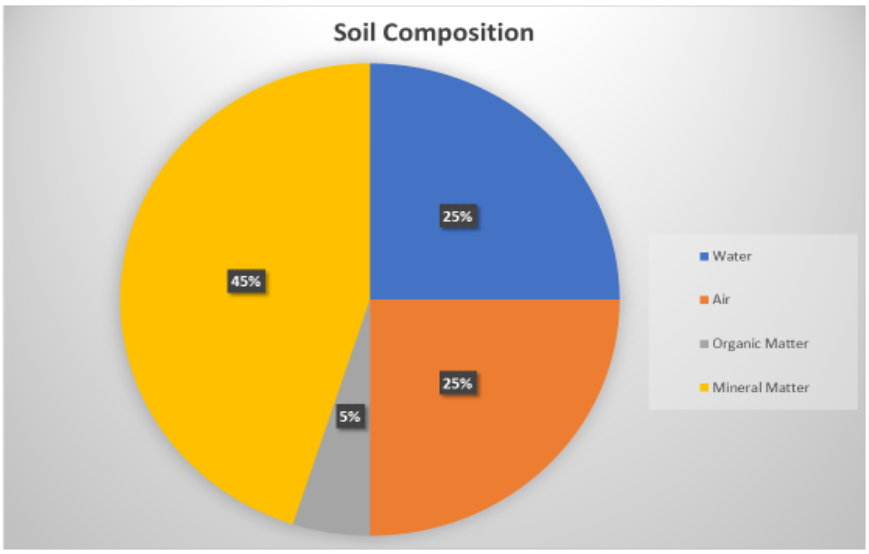
As the water moves, it carries dissolved minerals and other needed materials to the leafy "solar factory." The ability to replace water lost from the leaf quickly is one reason certain plants can handle full sun. Shade-loving plants are able to function better in the shade as the environment puts less strain on their inefficient root and leaf systems.

Many plants, like azaleas, often suffer in poorly drained, full-sun situations. Other plants, such as junipers, may do well in full sun because their leaves are adapted to lose smaller amounts of water. These adaptions may include smaller, furry, or waxy leaves.

Soil Science Concepts

- **Soil Composition –** naturally-occurring soils are approximately 50% mineral particles with about 1% organic matter in the southeast

The other half of the soil is about 25% air and 25% water in the soil pore spaces. Soils that are overly saturated with rain or irrigation water are also very low in soil air, leading to root and plant death.

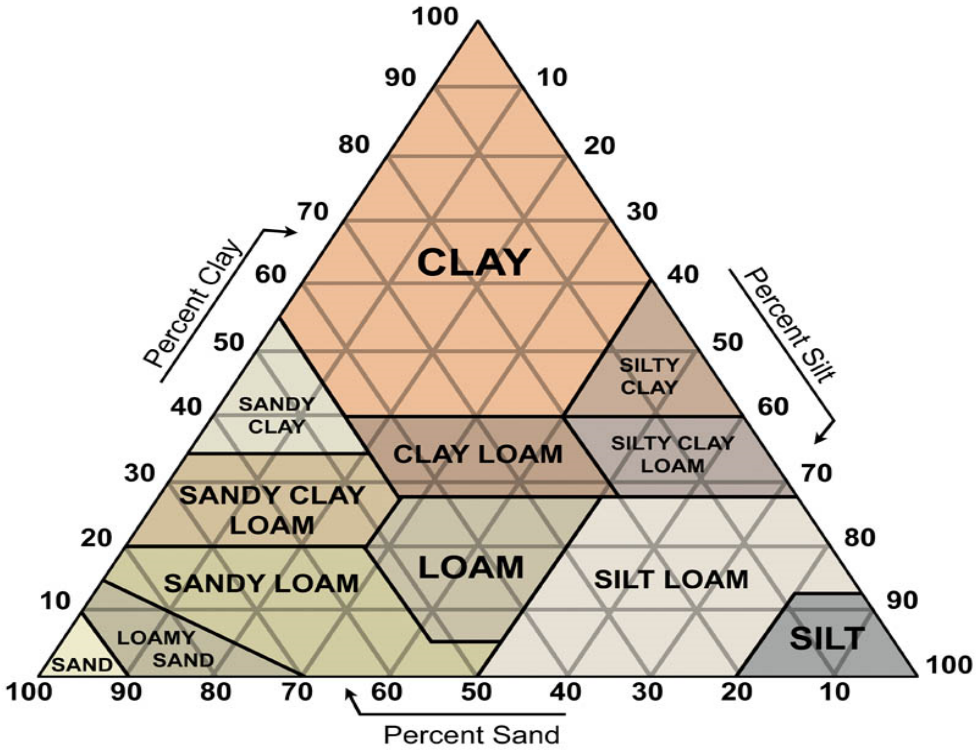


- **Soil Texture** – the proportion of sand, silt and clay particles in the soil

Determined by a particle separation test, texture helps to indicate available oxygen, water needs, fertilization and liming programs, and quantities of pre-emergent herbicide to be applied.

Unless the budget is available to make wholesale changes, as in golf greens or sand based athletic fields, texture is difficult to change on a large scale.

The best advice is to thoroughly till or pulverize the soils, add some organic matter, lime as needed, and till again. The resulting soil will be of similar texture but better able to grow the desired plants.



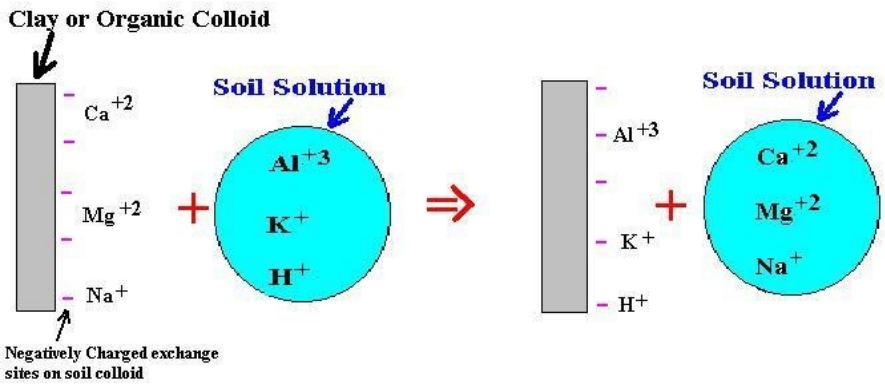
- **Soil structure** – the arrangement of the ingredients in the soil.

Soil structure can be improved by lime and organic matter additions and through proper tilling or spading. Excess tilling or preparing wet soils, compaction, and the use of cheap, high salt fertilizers may destroy soil structure.

- **Cation Exchange Capacity** – is the ability of the negatively charged clay and organic particles in the soil to hold and release positively charged nutrients in the soil or added as fertilizer

The CEC also helps indicate the amounts of pre-emergent herbicide, lime, etc. the soil can retain. Sandier soils will need smaller, more frequent additions of herbicides and fertilizers whereas clay soils respond well to higher, less frequent applications of both.

Cation Exchange Illustrated



- **Soil pH, acid and alkaline** – pH is a measure of the acidity or alkalinity of the soil.

It is based on a numerical range from 1 to 14, where 1 to less than 7 is acidic, 7 is neutral, and more than 7 to 14 is alkaline or basic.

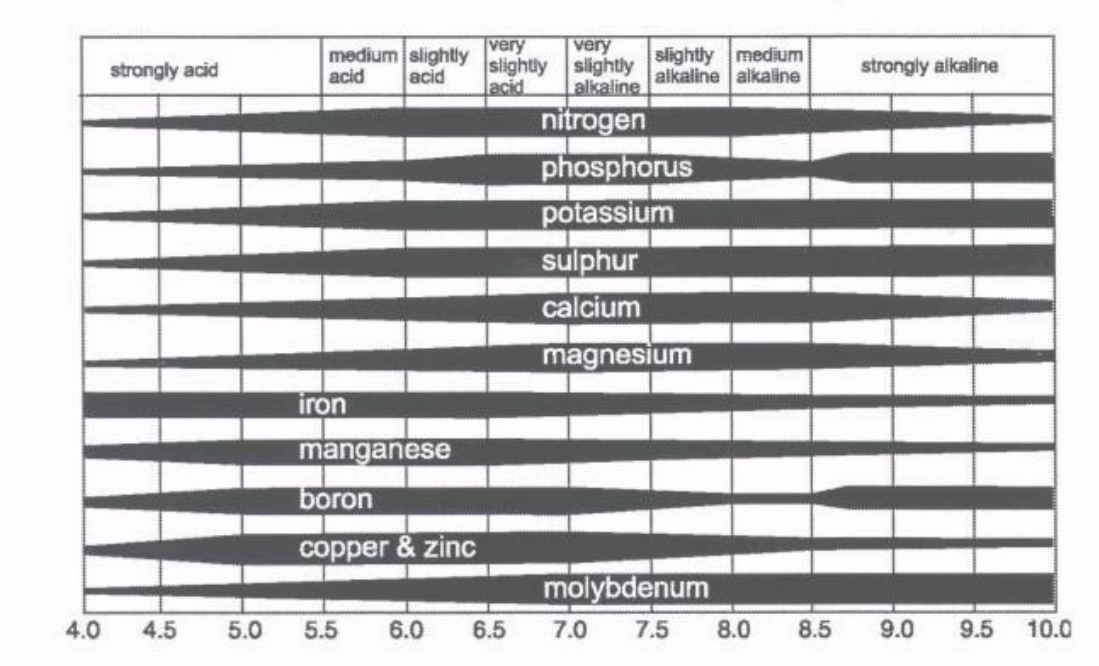
The pH of a soil is determined by a soil test, and indicates how much lime is needed to raise the pH (lowering the acidity), or how much sulfur, iron or aluminum amendments are needed to lower the pH (raising the acidity).

Liming Material	*Relative Neutralizing Value**
Calcitic Limestone	*85 – 100*
Dolomitic Limestone	*95 - 108*
Burned Lime	*179*
Hydrated Lime	*120 - 135*
Gypsum	*None*

The pH affects the uptake of nutrients, water infiltration, the decomposition of organic matter, and the growth of beneficial microbes and much more in the soil.

Some plants such as centipede, azaleas, camellias, blueberries and red oaks do their best in acidic soils. Plants like these will show interveinal **chlorosis** or yellowing due to a pH so high that iron and other micronutrients are unavailable.

In the chart below, the wider the band is at each pH reading, the greater the nutrient availability. For example, at a pH of 6 to 7 most nutrients are in a good supply. As the pH drops to 5.5 and less, many of the critical macronutrients like N, P, K, Ca, and Mg become much less available and micronutrients like Fe, Cu, and Zn become more available. This is the reason why plants growing in alkaline soils often show iron deficiency symptoms and turf, trees, and flowers don't respond well to nitrogen applications in low pH soils.



- **Hardpan** – is a layer of hard soil that roots cannot grow through

In some cases, subsoiling, deep tilling or spading may alleviate the problem.

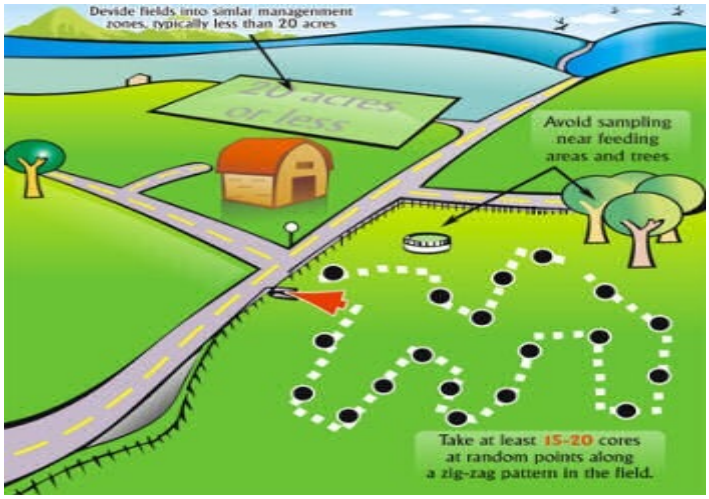
- **Percolation test** – a field test to determine if soils have adequate internal drainage

Auger or dig a posthole 12" deep, fill with water and check at 12 hours. If the hole is not free of water by 8 to12 hours, French drains, berms, or other solutions should be employed.

- **Soil sampling** – a procedure in which the technician obtains many subsamples at the crop's proper root depth and creates a representative sample for the whole area

Many problems exist with this method as most urban landscapes have soils that vary greatly in short distances.

Tools needed are a bucket, soil probe or trowel, and a soil test information sheet and mailing box from the county extension system office.



Soil sampling publications: http://www.aces.edu/pubs/docs/A/ANR0006A/ANR0006A.pdf & http://www.aces.edu/pubs/docs/A/ANR0006B/ANR0006B.pdf

- **Organic** – compounds containing carbon, usually a word used to describe an amendment that comes from a living source like manures, composts and decomposed bark fibers

Many southeastern soils are very low in organic matter and all types seem to benefit from some organic matter additions. Organic matter helps the soil hold water and nutrients, and encourages the growth of beneficial microbes.

Organic mulches like pine bark and pine straw decompose over time and add organic matter back to the soil. Keep in mind that in the case of sand-based golf course greens and athletic fields, where drainage is critical for play, excess organic matter may need to be removed through core aeration and topdressing with sand.

- **Inorganic** – amendments that come from sources that are non-living; both naturally occurring minerals and the synthetics, such as petroleum-based fertilizers

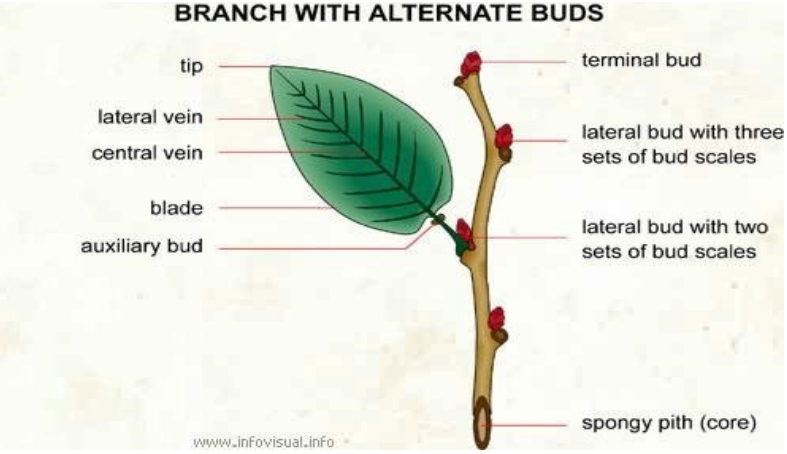
Mulches made of volcanic rock, gravel, chipped tires, and plastic pine straw are inorganic and do not seem to improve the existing soil and may increase soil temperatures. They often become a nuisance and look bad as leaves and trash build up in the beds.

Plant Anatomy

- **Adventitious buds** – hidden growth points found under the bark in some plants such as yaupon or 'Burford' holly that help predict how well they respond to renovation pruning.

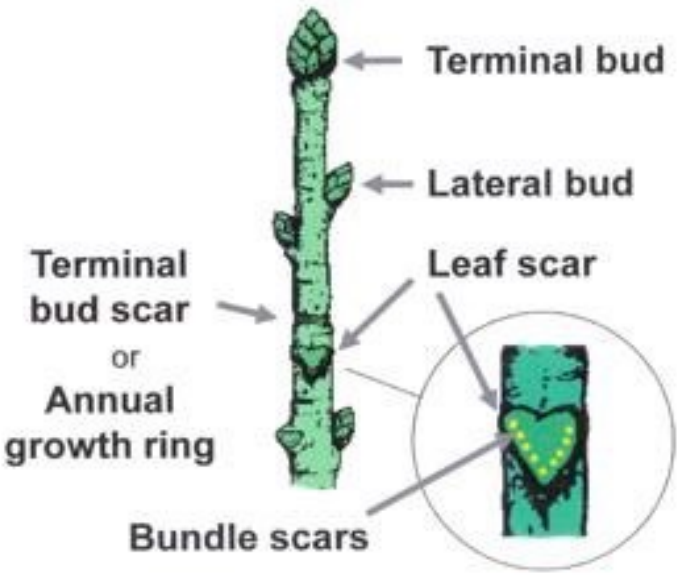
Plants like juniper, pines, boxwood, and azalea are less likely than others to regrow due to having fewer adventitious buds. In other words, severe pruning of a juniper will likely kill it, while with severe pruning of a yaupon holly, it will grow back.

- **Lateral buds** – growth points found between the leaf petiole and the stem on a plant. Lateral buds can be forced to grow by removing the terminal bud or the lateral just above. Depending on the plant, pruning cuts only affect lateral buds about 8" away from the cut.



- **Apical or terminal buds** – the growth point at the tip of a branch or shoot. Hormones like auxin, with the help of sunlight, keep the apical bud dominant in growth habit.

Removal of the apical bud by pinching or pruning will cause the bud below it to "break" or begin to grow.



- **Leaves, midrib, blade and petiole** – leaves are the solar collectors that turn light energy into simple sugars and other compounds.

For that reason, they usually are green or some close variation. Some leaves have bands or spots of gold, yellow or silver mixed in with the green and are referred to as variegated.
The main vein on certain leaves is called the midrib. The flat part of the leaf is the blade, and the small stem that holds the blade to the shoot is the petiole.

Leaves can be deciduous and lose all of their leaves in a short time period, as happens in the fall. Plants like dogwood, oak, maple, and hydrangea are deciduous.

Leaves may also be evergreen, which means they lose their leaves a certain percentage each year, such as happens with pines, hollies, and azaleas.

- **Roots** – the usually underground part of the plant responsible for anchorage, water and mineral uptake and food storage in the plant

Roots grow best in optimum levels of soil, air, and water, and die in soils that are too dry or wet. Most roots are found in the top two feet of the soil, depending on the soil type and plant.

Cutting or filling around plants will often kill roots and sometimes the plant itself.

- **Stems, branches & trunks** – supportive and connective tissue found in most plants

Water and nutrients pass through these tissues so improper pruning and mechanical damage may kill the plant. All green plant parts are capable of making food, so be careful spraying any herbicides on these tissues.

- **Buds, flowers and fruit** – the reproductive parts of the plant, leading to seed formation and new plants

For most customers, these traits may be their main concern with plant selection. Try to balance these traits with overall plant growth habits, disease resistance, and required plant maintenance levels.

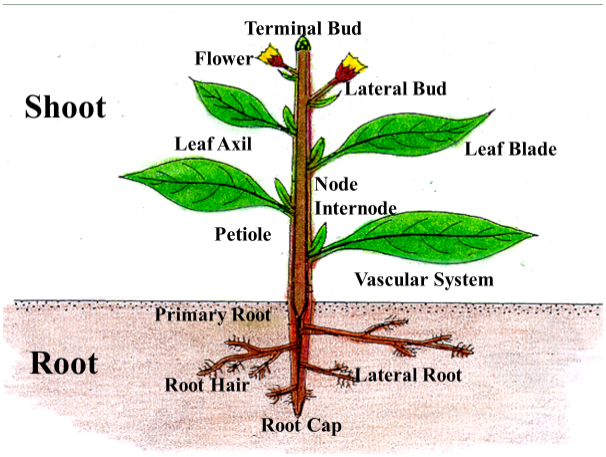
In some cases, flowers and fruit may attract pests or lead to slips and falls, so take care in their installation location and cleanup. In public properties, lawsuits for sidewalk debris slip and falls are becoming more common.

- **Xylem, phloem and cambium** – tissue systems that make up the vascular parts of plants

- **Cambium** is the very active, green growth area just under the bark.

Cambium is comprised of **xylem**, which carries water and dissolved minerals up the tree, and **phloem**, which transfers processed food down the tree to storage or use sites.

The growth rings found in most trees are due to the production of new cambium layers each year.



- **Water sprouts** – rapidly growing, straight shoots that grow from branches, perhaps wasting energy and destroying the plant's form.

Water sprouts can be used to regrow or rejuvenate older trees if proper pruning techniques are used.

- **Suckers** – rapidly growing, straight shoots growing from the root system.

Suckers found at the base of plants like cherries, crape myrtles, crab apples, and wax myrtles are messy and can be pruned back to the point of attachment with bypass pruning shears. Shearing them off with lawn mowers and string trimmers can lead to disease and damage and should be avoided.

Pruning Methods

- **Pruning Timing** – the guiding principle for pruning flowering shrubs is known as the May Rule.

The **May Rule**, with a few exceptions, states that if a plant flowers before May 1st, prune just after blooming. Plants that bloom after May 1st should be pruned before growth starts in the spring.

For example, plants like azalea, forsythia, quince, viburnums, many spireas, and nandinas that bloom before May 1st, should be pruned right after bloom.

Plants that bloom after May 1st, including tea olives, crape myrtles, abelia, butterfly bush, southern magnolias, and gardenia should be pruned before spring growth starts.

Plants that are non-blooming can be pruned any time that resulting growth will not be damaged by heat or cold.

- **Pruning conifers** – cone-bearing plants are known as conifers and include junipers, cedars, cypress, arbor vitae, yew, and pine

Conifers do not respond well to shearing and/or heavy renovation pruning. When pruning conifers, always prune branches just above leaves or branches. Removing all the foliage from a conifer branch will usually kill the branch.

- **Selective pruning** – a pruning process that removes one branch at a time as opposed to shearing

If done properly, selective pruning improves plant openness, health, and accentuates natural form. Selective pruning is a high-skill activity, demanding the horticulturist have a thorough knowledge of plants and their growth habits and forms. Because it is a slow process, selective pruning can be much more expensive than shearing.

Sheared Holly

Selectively Pruned Holly

See Proper Pruning: https://pubs.ext.vt.edu/430/430459/430459_pdf.pdf

- **Shearing** – formal, rigid pruning that turns plants into hedges or other shapes not found in nature.

Practiced to excess by the ancient Romans and the French aristocracy, the shearing of plants should be left to fine formal landscapes, certain hedges and Disneyworld. Most shearing today is carried out because the service provider or customer doesn't know better or the budget is tight. Shearing is bad for most plants.

From a personal safety standpoint, the use of power shears without proper Personal Protective Equipment is a common cause of personal injury and an important reason to keep company insurance updated.

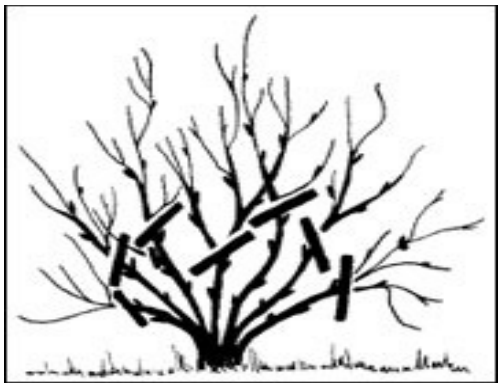
- **Thinning** – the pruning method that involves reaching deep into a plant to remove or shorten a branch

Thinning is the method that best accentuates natural plant form and improves the health and appearance of plants.

thinning cuts

Heading back – removal of a branch at a location at or near the edge of the canopy.

Heading back is best used to fill in bare areas, but leads to rapid regrowth and a dense outer layer of shoots.



heading cuts

- **Anvil Type Pruners** – have a blade and anvil that lead to greater damage to plants stems when pruning

Their use is okay for tougher plants like holly and juniper as they are less likely to become damaged when used roughly. Whenever you can prune with bypass pruners, the results will be much better.

- **Bypass Pruners** – have blades that work like scissors, leading to a cleaner cut with less tissue damage

They are usually more expensive and can be damaged by cutting limbs over ½" diameter or through rough handling. Pruner blades should be kept clean and sharp and can easily be replaced as needed.

- **Pruning Saw** – normally a curved saw with a folding or fixed blade having coarse, wide-set teeth

Most pruning saws cut on the pull stroke and benefit from frequent oiling, cleaning and sharpening. Pruning saws can create terrific wounds to the user so it is best to wear safety gloves to limit personal damage.

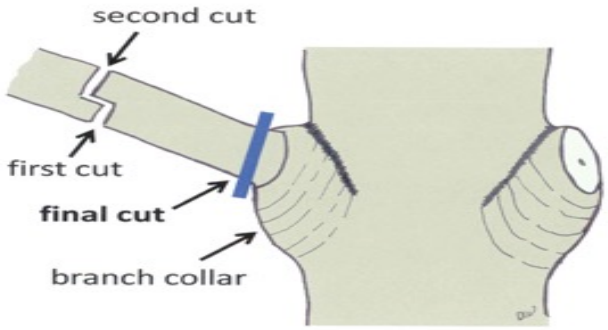
- **Loppers** – anvil or bypass pruners with a larger opening between the blades and longer handles to increase leverage for larger limbs up to one inch

- **Compartmentalization** – a term used by arborists to explain that plants don't heal damage, they seal or 'close over' damaged tissue and wall it off from the rest of the plant.

The sealing process includes natural barriers such as the growth **rings** and **rays** which keep the disease from spreading. This process uses up stored foods, so it is best to avoid damaging plants by hitting with mowers, string trimmers, or driving over their root systems. With continual damage, it is possible for a tree to compartmentalize itself to death.

- **Three-cut method for limb removal** – the recommended method for removing limbs from trees that are not small enough to be easily managed when removing

1. The first cut is an "undercut" made about one foot out from the point of attachment, from the underside of the limb to about one third the way in. This cut will keep the branch from tearing trunk bark and damaging the tree if you lose control of the limb.



2. The second cut is a "through cut" made just above or slightly outside the undercut, and is completed once the limb pops off.

3. The “finish” or final cut is made outside the bark ridge and branch collar and completes the process.

No wound painting or sealing is recommended, as it interferes with the natural closing of the wound. Please refer to the many videos, brochures and Power Points presentations that illustrate the process on the GIW Portal.

- **Bark ridge** – bark that is between the trunk and the attached branch; one of Dr. Alex Shigo’s targets to use when pruning limbs

- **Included bark** – bark that has little connective strength and often a source of limb failure in trees with narrow crotches. These trees include ‘Bradford’ pears, elms, and zelkovas

- **Collar** – tissue found on some tree limbs that indicate the transition between branch and trunk tissue

Properly cut limb wounds are rounder than pear shaped, as the cut is above the wider collar.

- **Topping** – a butchering process practiced by the uninformed to keep trees in a desired height range

The growth that results is rapid, weakly attached, and creates the need for more pruning. Large, decaying wounds in big limbs is a sign of tree topping. The practice of “Crape Murder” shown below is a real tree crime.

- **Pollarding** – a formal type of tree pruning that results in a smaller sized tree, without the resulting decay of a topped tree. If done well, it is very labor intensive.

Crape murder… (From ConnectSavannah)

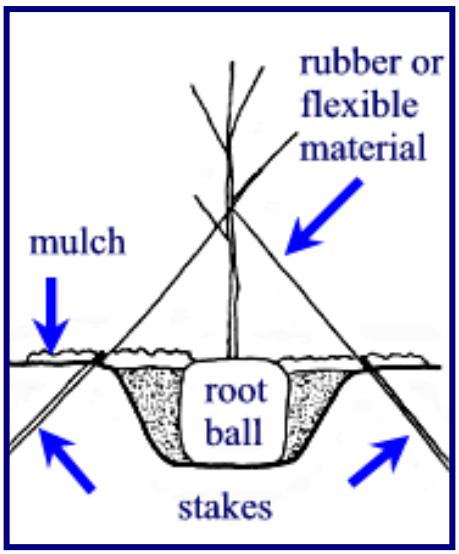
Proper pruning…

Staking and Guying Methods

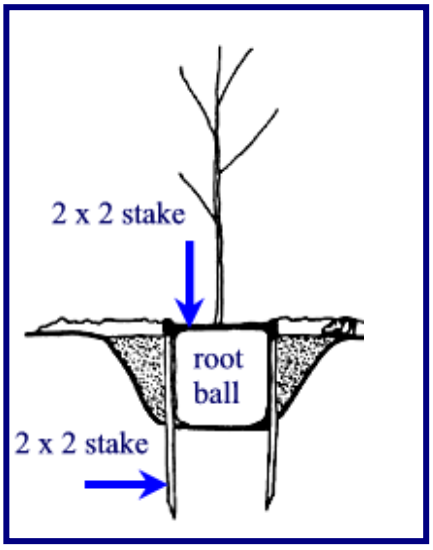
- **Root ball staking** – the concept proposed by Dr. Ed Gilman of the University of Florida that it is better to anchor the root ball without attaching guy wires to the trunk

Root ball staking allows the tree to flex and develop taper naturally. The staking of container trees involves driving untreated wooden 1x 2's through the roots into the subsoil. The two to four stakes are never removed as they decay over time.

With ball and burlap plants, the stakes may need to be 2x4's driven next to the ball and flush. Large trees may need connecting 2x4's for stability.



Traditional Staking



Root ball Staking

- **Not staking at all** – research has shown it is better not to stake the plant at all if it can support itself.

- **Wires, rubber hoses, strapping, etc**. – any material pulled tight on the trunk will cause girdling and cambium death over time.

Many "soft" hoses with wire have girdled and damaged trees. If you need to stake and guy the tree, wide cloth strapping is better than hose. If you feel you can't implement trunk staking, at least allow the guying to be loose enough for the tree trunk to sway and develop taper. Check and loosen strapping as needed over time to lessen damage.

Planting Methods

- **Plant Forms -** plants are produced and sold in three primary forms; bare root, container, and ball and burlap

Images from left to right: bare root, container and ball and burlap. (From Gene Wright, Urban Forestry South Manual.)

- **Bare root** – a plant production method where the plant is shipped without any soil and planted during the dormant season

Bare root trees are sold smaller and have a narrow planting window. It is better to soak the bare root plants in water for four hours before planting to encourage some water uptake.

When installing, a wide hole with a pedestal of tamped earth at the bottom is a good practice. Make sure the soil is pulverized and work the soil around the roots to insure stability and a well dispersed root system.

One stake driven next to the trunk and secured with a figure eight of cloth strapping is usually sufficient. Bare root plants are usually cheaper and often produce better adapted plants.

- **Container** – most container plants are growing in sawdust or a pine bark fines soil mix for many months and their roots tend to form to the shape of the pot.

It is critical to slice or score the roots as described earlier in order to allow the plant to regrow a proper root system in the planting bed. However, 2010 research from the University of Minnesota indicates that the scoring process may not correct containerized tree roots, leading to girdling and early death.

Try to water the containers several hours before installing in the landscape, remove carefully from the container, and score the roots. Make sure the entire planting bed is amended and tilled 8 to 10" deep if possible.

Install the plants with the top of the root system slightly above grade, perhaps 12", to allow for better drainage. Pulverize the native soil, if tilling was not possible, and backfill around the roots. Ramp the surrounding soil up to the top of the roots.

Never cover the roots with anything other than light mulch.

Soils, especially heavy clays, piled on the roots can lead to low oxygen levels in the roots and little infiltration of water. Newly installed container plants often dry quickly. The proper installation includes several visits after the job is complete to check on plant progress. Setting irrigation systems to take care of all the water needs of a new landscape is a recipe for failure. Irrigation systems are designed to water existing landscapes, not new installations.

Property managers and homeowners often do not understand the need to reset the system as plants root in. It is very likely that a new landscape will die from excess water if systems are not monitored frequently.

- **Ball and burlap** – may lose up to **90%** of their root system in the harvesting process and are subject to lots of initial transplant shock

Set the plant on a pedestal of firmed soil that keeps the ball from settling and allows the topmost root to stay at or above grade. Backfill as described above; there is no need to remove healthy branches to compensate for root loss. It is most critical to cut the tie string that holds the burlap around the top of the ball as this will girdle the stem if left in place.

Next, slice the burlap in several places, or remove if possible. Because of the low oxygen content of many clay soils, even natural burlap may take years to degrade. To determine if burlap is natural, light it with a match. Natural burlap turns to ash, while synthetic burlap turns to a plastic "goo." *All synthetic burlap* must be removed or pushed down from the ball.

- **Wire basket** – trees above 3” caliper may lose 90% of their existing roots in the harvesting process

For this reason, it is critical to handle the plants carefully and install as soon as possible. All the above B&B procedures apply, with the addition of removing the top tier of the wire basket.

Research differs on the harm caused by the basket wire, but there is little doubt that roots grow over the wire instead of pushing it out of the way. As trees increase in caliper, the wire will girdle the trunk. If nothing else, cut the seatbelt fabric strapping that holds the basket to the trunk. Strapping left in place will girdle the trunk over time.

Again, root ball staking and planting on a firmed pedestal will keep the tree from settling or shifting.

- **4” pots and cell packs** – water before removal and tease or slice the root ball to help get the roots out of their spiral

Be very careful not to cover annual roots with soil or piles of mulch. Less is better around the crown of the plant. Pine straw and large chunk or shredded bark is often looks bad and is difficult to apply around annuals and small groundcovers.

- **Call the Line Locator at 811 before digging!**

One incident with a power or gas line can be fatal and cutting one fiber optic cable could destroy your business. In most states; you must call three days before you dig. Fines up to $2,000,000 are possible!

- **Planting pit size and depth** – these need to be two to three times the root ball diameter and shallower than the ball to discourage settling

If the site is tilled, there is no need to dig a hole larger than the root ball. Proper tilling can save labor dollars, energy *and* improve your results!

- **Planting pit shape** – not very important if the entire bed is tilled. For individual plants, wider is better

- **Condition of backfill** – backfill with native, pulverized soil.

Research from the University of Georgia shows no real improvement in plant growth by adding organic matter to a planting *hole*. Adding several inches of organic matter to a *planting bed* is very helpful. Till afterward to make a homogeneous mixture.

If you till a vegetable garden and add compost before planting a dollar tomato plant, shouldn't the $100 boxwood deserve the same? If you don't expend the energy to prepare the soil, the work will have to be done by the plant, if it survives long enough.

Whenever possible, till the soil thoroughly before installing any plants!

- **Height of root ball** – this should always be at or above grade in poorly drained clay soils

Try to find the topmost root in the root ball and set it at or above grade. In sandy soils, the ball can be at grade but no deeper. Plants that settle below grade often are stunted and slowly die over time. Tamp the loose soil below the root ball before installing the tree.

- **Drainage and oxygen content** – provide for proper drainage and oxygen content by routing downspouts out of the bed, allowing for proper slope away from the foundation, properly designing irrigation, and amending and raising with composted pine bark fines.

Low oxygen soils have an odor like methane or sewer gas and often have roots standing in water. Some plants like Virginia sweet spire, bald cypress, birch, and inkberry holly can handle wetter soils, but most plants prefer lots of drainage and oxygen in the soil.

- **Fertilization** – again, there is controversy, but add fertilizer to your tilled soil according to your soil test results

Nitrogen is not recommended initially for most plants, although some disagree, but never right before cold or drought conditions occur. Phosphorous, potassium, and lime levels should be addressed before installation begins.

Landscape Mulches: http://www.aces.edu/pubs/docs/A/ANR0385/ANR0385.pdf

Care and Management of Landscape Plants: http://www.aces.edu/pubs/docs/A/ANR0958/ANR0958.pdf

- **Root flares** – roots tapering off the tree trunk that become more exposed as their diameter increases

Do not cut, fill, or heavily mulch root flares as the tree will suffer. Fertilizer, herbicides, trenchers, and mowers should not get close to flares for the same reason. Fungal diseases, such as Armillaria root rot, often move into damaged root flares, killing the tree.

- **Girdling root** – roots that grow around the trunk or root flares, eventually killing the plant

Not scoring or cutting the roots one inch deep in several places on a container plant before installing in the landscape can lead to girdling roots. New research shows that girdling roots are also caused by deeply mulching landscape plants or shifting (bumping up) nursery stock too deeply.

Large girdling roots may be cut to allow trunk expansion, but in some cases “the cure also kills the patient.”

Removing a stem girdling root. _

- **Root or pot bound** – a condition in which plant roots take the form of the container they are in, leading to stunting and perhaps even death.

Making three to four 1” deep cuts down the root ball will sever roots and encourage plant health.

Turf Management

- **Over-seeding** – refers to the use of ryegrass planted in an existing warm season grass like Bermuda or zoysia during the dormant season

Although over-seeding helps with preventing wear on athletic turf, over seeded lawns often suffer from the added plant competition. During cool springs, rye may not die out, leading to the warm season turf weakening and failing.

Ryegrass is also a very wet turf, which leads to mowing problems and certain diseases such as Pythium blight.

- **Fertilization** – it is best to keep turf a little on the hungry side and not push lawns to be too green from excess nitrogen

Over-fertilization leads to pollution, wasted maintenance dollars, and insect and disease problems. Many industry professionals are cutting down on frequency and amount of fertilizer by using slow release carriers and encouraging deep root growth through core aerification.

Turf fertilization programs vary, but the following rates of actual nitrogen per 1,000 square feet are traditional starting points:

1. Bermuda – 4 to 6 lbs.
2. zoysia, St. Augustine, and fescue – 3 to 4 lbs.
3. centipede – 1- to 2 lbs.

High quality, slow-release fertilizers low in salt will more likely give the turf manager the best results. Using high tech fertilizers like Spread It and Forget It, many turf managers have cut both the number of applications and the total pounds of fertilizer applied in half.

Granular fertilizers are often the best choice for turf, but liquid inorganics and organics are also very useful. Liming according to a soil test is necessary to achieve the most from a turf fertility program.

- **Core Aerification** – pulling soil cores with a machine on a pattern of 4 to 6” apart over the entire lawn

The cores are then broken up with a mower and left to decompose the thatch in the lawn. Thatch plus soil equals mat, an excellent material for grass roots to thrive!

Aerification also improves water infiltration, rooting depth, and lessens the effects of compaction. Warm season turf should only be aerified after green-up and before the transition begins to dormancy. In most years in lawns can be aerified May through August if irrigation is available. Cool season grasses are best aerified in the fall, usually when over seeding is accomplished.

- **Irrigation** – water turf deeply and infrequently. Frequent, shallow watering leads to poor root depth, disease, and wasted fertilizer and pre-emergent herbicides

Cool season turf is most at risk during the summer and irrigation may be used to cool hot spots and lessen plant stress. Professionals need to transition towards weather and soil-linked controllers as a replacement for clock controllers which lead to water waste.

Most sites will benefit from frequent irrigation audits to discover leaks and damaged heads and irrigation should be on a separate meter to save the customer the expense of being charged for sewage costs on landscape water.

- **Soil preparation** – turf grows the best on amended and tilled soils that are graded to allow for proper runoff of water

Lawns that are flat, or have less than a 2% slope, will suffer from saturated soils and lack of oxygen and will benefit from a tile drainage system.

Seeding or sodding compacted or scraped soils is a poor practice at best. Lime and fertilize according to your soil test.

- **Mowing** – turf should be mowed so no more than 1/3rd the canopy is cut off at one time.

This **"1/3rd Rule"** allows for turf to always be able to produce sugars for growth. Scalping (cutting lawns too far back) causes turf to lose stored food and encourages weed growth.

Always mow turf with a properly sharpened blade. For best results, blades should be sharpened after 4 to 6 hours of mowing.

Several included bulletins on turf recommend mowing Bermuda as low as ½". Low mowing heights are maintainable if the frequency of cut is 3 to 5 days and the lawn is very smooth. In most settings, turf maintained at 2"+ will have less weeds, more stored food and a deeper root system. Cool season turf almost always performs better at higher mowing heights.

Selecting Turfgrass: http://www.aces.edu/pubs/docs/A/ANR0092/ANR0092.pdf

Establishing Lawns in Virginia: http://pubs.ext.vt.edu/426/426718/426718.html

Bermuda Lawns: http://www.aces.edu/pubs/docs/A/ANR0029/ANR0029.pdf

Zoysia Lawns: http://www.aces.edu/pubs/docs/A/ANR1129/ANR1129.pdf

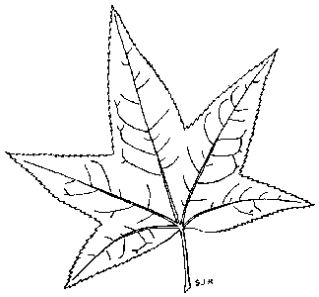
Centipede Lawns: http://www.aces.edu/pubs/docs/A/ANR0073/ANR0073.pdf

St. Augustine Lawns: http://www.aces.edu/pubs/docs/A/ANR0262/ANR0262.pdf

Plant Identification and Samples

- **Leaf types** – leaves can be described as *simple* or *compound* and/or *pinnate* or *palmate*.

Simple leaves have only one leaf blade, joined by its stalk to the woody stem and includes most trees and shrubs including holly, azalea, maple, oak, cherry, dogwoods, and aucuba.



Simple

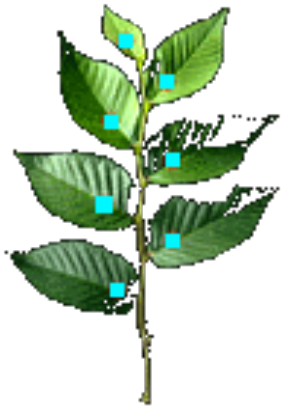
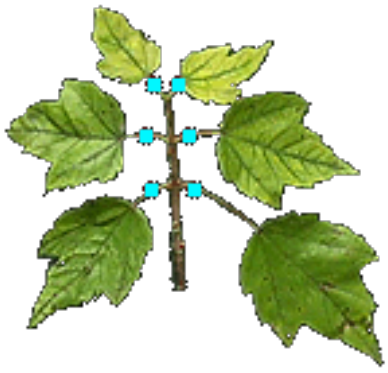
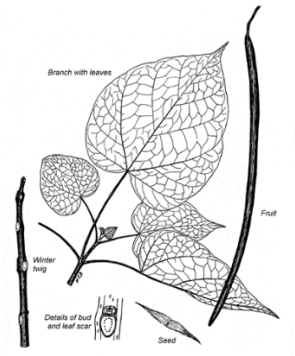
Compound

Compound leaves are made up of several leaflets that are attached to a non-woody midrib and include trees and shrubs like sumac, mimosa, hickory, nandina, and mahonia.




Simple versus Compound Bi-pinnately Compound or Palmately Compound

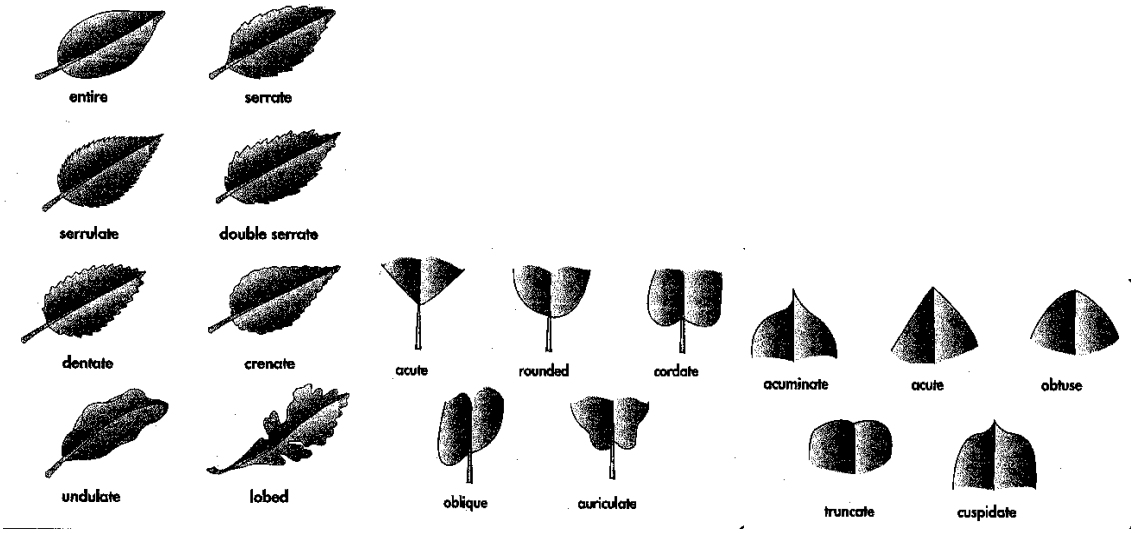
- **Leaf Position** – leaves can be described based on their leaf position as *alternate, opposite or whorled*

alternate opposite whorled

- **Leaf margins, tips and bases** – are often used to identify tree species and cultivars and are as follows:

  Leaf margins – Entire, Serrate, Dentate, Lobed
  Leaf tips – Acuminate, Acute, Obtuse, Truncate
  Leaf bases – Rounded, Cordate, Acute



Leaf Margins Leaf Bases Leaf Tips

- On your exam, a sample of 'Blue Rug' juniper will simply be identified as a "juniper"

The goal is not to ask your students or the employee to become an expert in plant ID, but to become familiar enough that he has a good foundation for future growth and can follow direction in the field. For example, an employee with this certification should be able to complete an assignment to selectively prune the hollies on the west side of the building.

Below are some examples of plants that may be found on the exam. The plants listed below can be found on the GIW website plant ID Power Points. The exam will NOT be limited to these plants. Please study all samples provided during class.

Common Name	**Botanical Name**	**Sun/Shade**	**Size Height X Width**
Broadleaf Evergreen Shrubs			
Japanese Pittosporum	*Pittosporum tobira*	Sun to Part shade	15 ft X 15ft
Korean Littleleaf Boxwood	*Buxus microphylla var. koreana*	Sun to Part shade	2' X 2.5ft

Japanese Pieris	*Pieris japonica*	Sun to Part shade	912 X 68ft
Japanese Camellia	*Camellia japonica*	Part shade	1015 ft X 10 ft
Burkwood Daphne	*Daphne X burkwoodii*	Part shade	5 ft X 5ft
Florida or Purple Anise Tree	*Illicium floridanum*	Part shade	610 ft X 610ft
Pink flowering Fringe Flower	*Loropetalum chinense var. rubrum*	Sun to Part shade	610ft X 610ft
Heavenly Bamboo	*Nandina domestica*	Sun to shade	Dwarf forms 1.54’
Japanese Fatsia	*Fatsia japonica*	Full shade	610ft X 610ft
Burkwood Viburnum	*Viburnum X burkwoodii*	Sun to part shade	812 ft X 812ft
Fragrant Tea Olive	*Osmanthus fragrans*	Sun to Part shade	630 ft
Indian Hawthorn	*Rhaphiolepis indica ‘Pink Lady’*	Sun or light shade	36ft X 36 ft

Spring Flowering Shrubs			
Snowmound Spirea	*Spiraea nipponica ‘Snowmound’*	Full to Part shade	35 ft X 35 ft
Vanhoutte Spirea	*Spiraea X vanhouttei*	Full sun	8 ft X 10 ft
Weigela	*Weigela spp.*	Full sun	10 ft 12 ft
Cherry laurel	*Prunus laurocerasus* ‘Otto Luyken’	Full to Part sun	4 ft 6 ft
Japanese Snowball Viburnum	*Viburnum plicatum*	Full sun	815ft
Forsythia	*Forsythia X intermedia*	Full sun	810ft X 1012 ft
Common Flowering Quince	*Chaenomeles speciosa*	Sun to Part shade	610ft X 610ft

Large Fothergilla	*Fothergilla major*	Sun to Part shade	610ft X 610ft
Fragrant Daphne	*Daphne odora*	Part shade	34 ft X 34ft
Red Buckeye	*Aesculus pavia*	Sun or light shade	1020 ft
Slender Deutzia	*Deutzia gracilis*	Sun to part shade	24 ft
Summer Flowering Shrubs			
Anthony Waterer Spirea	*Spiraea japonica* 'Anthony Waterer'	Full Sun	24ft
Doublefile Viburnum	*Viburnum plicatum* var. *tomentosum*	Sun to Part shade	810ft X 810 ft
Oakleaf Hydrangea	*Hydrangea quercifolia*	Part shade	46 ft X 46 ft
Endless Summer Hydrangea	*Hydrangea macrophylla* 'Baimer'	Morning sun and afternoon shade	35 ft X 35 ft
Rose of Sharon	*Hibiscus syriacus*	Sun to Part shade	812 ft X 812 ft
Virginia Sweetspire	*Itea virginica* 'Henry's Garnet'	Sun to light shade	46 ft X 46 ft
Petite Plum Crape Myrtle	*Lagerstroemia indica* 'Petite Plum'	Full sun	5 ft X 4 ft
Glossy Abelia	*Abelia X grandiflora*	Sun to Part shade	36 ft X 36 ft
Limelight Hydrangea	*Hydrangea paniculata* 'Limelight'	Sun to Part shade	810 ft X 6 ft
Carolina Allspice	*Calycanthus floridus*	Sun to Part shade	69 ft X 69 ft
Butterfly bush	*Buddleja davidii*	Full sun	812 ft X 812 ft

Groundcovers for shade			
Periwinkle	*Vinca minor*		68” X 36”
Wild Ginger	*Asarum* sp.		610” X 1224”
Japanese Pachysandra	*Pachysandra terminalis*		68” X 24”
Mondo Grass	*Ophiopogon japonicus*		816”
Aaronsbeard St. Johnswort	*Hypericum calycinum*		1218” X 1218”
Himalayan Sarcococca	*Sarcocca hookeriana* var. *humilis*		1224” X 1224”
Lenten Rose	*Helleborus sp.*		1824” X 1836”
Moneywort	*Lysimachia nummularia* ‘Aurea’		Hugs the ground X 4 ft
Carpet Bugle	*Ajuga reptans*		68” X 18”
Spotted Dead Nettle	*Lamium maculatum*		618” X 2436”
Cast Iron Plant	*Aspistra elator*		12 ft X 12 ft
Red Epimedium	*Epimedium X rubrum*		813” X 12”
Groundcovers for sun			
Tworow Stonecrop	*Sedum spurium*		4” X 24”
Lambs Ear	*Stachys byzantina*		18” X 18”
Creeping Thyme	*Thymus serphyllum*		6” X 18”
Cheddar Pink	*Dianthus* sp.		12” X 24”
Catmint	*Nepata faasenii*		1236”X 1236”
Wintercreeper	*Euonymus fortunei*		8” X 36”
Creeping Juniper	*Juniperus horizontalis*		24” X 6’
Creeping Phlox	*Phlox subulata*		6” X 1824”

Evergreen Candytuft	*Iberis sempervirens*		810” X 12”
Rockspray Cotoneaster	*Cotoneaster horizontalis*		25 ft X 10 ft
Creeping Raspberry	*Rubus pentalobus*		6” X 30 ft
Winter Jasmine	*Jasminum nudiflorum*		34 ft X 47 ft
Perennials for sun			
Beebalm	*Monarda didyma*		24 ft X 3 ft
Showy Stonecrop	*Hylotelephium* ‘Herbstfreude’		18” 24”
Russian Sage	*Pervoskia atriplicifola*		34’
Pincushion Flower	*Scabiosa columbaria* ‘Butterfly Blue’		18”24” X 18”
JoePye Weed	*Eupatorium maculatum*		56 ft X 34 ft
May Night Salvia	*Salvia superba* ‘May Night’		18”
Black eyed Susan	*Rudbeckia fulgida*		23ft
Purple Coneflower	*Echinacea purpurea*		24 ft X 2 ft
New England Aster	*Aster novaeangliae*		35 ft X 2 ft
Beardtongue	*Penstemon spp.*		30” X 24”
Cheddar Pink	*Dianthus* ‘Bath’s Pink’		6” X 12”
Mexican Sage	*Salvia leucantha*		
Perennials for Shade			
Bleeding Heart	*Dicentra spp.*		12” to 18” X 18”
Alum Root	*Heuchera spp.*		12”24” X 12“24”
Columbine	*Aquilegia spp.*		15”20” X 24”
Forget me not	*Myosotis sylvatica*		618” X 1824”

Lenten Rose	*Helleborus orientalis*		1518”X 15”
Sweet Woodruff	*Galium odoratum*		68” X 24”
Cardinal Flower	*Lobelia cardinalis*		34 ft X 2ft
Fragrant Hosta	*Hosta plantaginea*		1.5 ft X 2 .5 ft
Blue Woodland Phlox	*Phlox divaricate ssp. laphamii*		810” X 1215”
European Wild Ginger	*Asarum europeum*		610” X 24”
Christmas Fern	*Polystichum acrostichoides*		2 ft X 2 ft
Holly Fern	*Cyrtomium falcatum*		2 ft X 2 ft
Autumn Fern	*Dryopteris erythrosora*		2.5 ft X 2.5 ft
Shade Trees			
River Birch	*Betula nigra*	Sun	4070 ft
Tuliptree	*Liriodenron tulipfera*	Sun	7090 ft
Littleleaf Linden	*Tilia cordata*	Sun	6070 ft
Golden Raintree	*Koelreuteria paniculata*	Sun	2535 ft
White and Red Oaks	*Quercus sp.*	Sun	5060 ft plus
Sycamore	*Platanus occidentalis*	Sun or Light Shade	15100 ft
Southern Magnolia	*Magnolia grandiflora*	Sun best in Part Shade	6080 ft
Black Gum	*Nyssa sylvatica*	Sun or Part Shade	3050 ft
Bald Cypress	*Taxodium distichum*	Sun	5070 ft
Lacebark Elm	*Ulmus parvifolia*	Sun	4050 ft
Persimmon	*Diospyros virginiana*	Sun	3560 ft
Japanese Zelkova	*Zelkova serrata*	Sun	5060 ft

Ornamental Grasses, Sedges, and Rushes			
Feather Reed Grass	*Calamagrostis X acutiflora* 'Karl Foerester'	Sun or Part Shade	24 ft
Tufted Hair Grass	*Deschampsia cespitosa*	Part Shade	3 Ft X 2 ft
Silver Grass	*Miscanthus sinensis*	Full Sun to Part Shade	47 ft X 36 ft
Pink Muhly Grass	*Muhlenbergia capillaris*	Full Sun to Part Shade	3 ft X 3 ft
River Oats	*Chamanthium latifolium*	Part Shade	2 ft X 4 ft
Silky Thread Grass	*Nassells tenuissima*	Sun	18" X 12"
Evergold Sedge	*Carex oshimensis* 'Evergold'	Sun to Part Shade	12" X 18"
Japanese Sedge grass	*Cares morrowii* 'Variegata'	Part Shade to Full Shade	18" X 24"
Soft Rush	*Juncus effuses* var. *effusus*	Full Sun	14 ft

Trouble-Free Landscape Plants of Virginia: http://www.pubs.ext.vt.edu/450/450236/450236_pdf.pdf

Other resources for reference include Oregon State Landscape Plants, see http://oregonstate.edu/dept/ldplants and North Carolina's searchable landscape plants data base, see https://plants.ces.ncsu.edu/.

Integrated Pest Management

Those preparing for the LM Cert exam should be able to discuss or explain the following IPM concepts.

- The IPM process from pest identification through management.
- Basic knowledge of insect identification, life cycle and biology.
- Weed biology, identification, and management.
- Disease biology, identification, and management.
- Pesticide safety, handling, and use.
- **IPM** Integrated pest management (IPM) is an ecosystem based strategy that focuses on long term prevention of pests or their damage through a combination of techniques such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties.

Pesticides are used only after monitoring indicates they are needed according to established guidelines, and treatments are made with the goal of removing only the target organism. Pest control materials are selected and applied in a manner that minimizes risks to human health, beneficial and non-target organisms, and the environment.

- **Managing Pests and Consumers** – consumers have little patience with landscape and turf pests and often set very low thresholds for weeds in lawns and pests on shrubs and trees

These low thresholds and customer complaints create a situation where the Pest Management Professional feels obligated to use "high powered" pesticides to keep the consumer happy. As a partial solution, try to implement the following:

1. Set reasonable expectations with the customer. Reasonable consumers will realize the presence of a few weeds, blemished leaves or an insect or two do not make a landscape a failure. If your education program doesn't work, you may decide that the customer is unreasonable and perhaps you would be better off without them.

2. Use resistant varieties where possible. Crape myrtles that avoid powdery mildew, roses that don't get black spot and Indian hawthorns that are less bothered by leaf spot are superior choices and will lessen the need to apply pesticides.

3. Install plants properly. Lack of proper soil preparation and grading, installing the wrong plant for the site and planting and/or mulching too deeply are major causes of plant failure.

4. Don't over-water or over-fertilize your lawn and landscape. Many turf weeds, insects and diseases are made much worse under high water and fertilizer programs. High nitrogen containing lawns are more attractive to pests like brown patch and armyworms and help create lots of weeds like nutsedge.

5. Keep the landscape clean and well maintained! Weeds and dead leaves in shrub beds, uncut grass, and overgrown shrubs encourage pest problems.

6. Soaps and Oils are excellent choices for ornamental and turf pest management programs. As a general rule, we often recommend several dormant or light oil applications per year to shrubs and trees to lessen the buildup of harmful pests. Soap sprays such as M-Pede can be used as needed to suppress populations of scales, whiteflies, aphids, etc. Products like kaolin clay, diatomaceous earth, neem oil, etc. are excellent choices in certain landscapes.

A few thoughts about using pesticides:

1. Always read, comprehend, and follow the pesticide label. Pesticides are labeled "site specific" and can only be used on sites found on the label. Sites listed may include residential, commercial, right-of-way, agriculture, etc. For example, using a pesticide labeled for commercial sites may be illegal when applied to residential sites.

2. Pesticide toxicity is measured in part through the LD_{50} and some synthetic pesticides, such as the herbicide, Roundup, are less toxic than the "organic" approved herbicide, acetic acid or vinegar. When referring to LD_{50} levels, remember that pesticides with low LD_{50} levels are MORE poisonous than pesticides with higher numbers. For example, pesticide A with an LD_{50} level of 100 is much more poisonous than pesticide B with and LD_{50} of 1,000.

3. Since the 1970s, under the oversight of the Environmental Protection Agency (EPA), the industry has greatly reduced the toxicity of conventional pesticides. They have also done a great job in changing the chemistry so that products are less likely to harm non-target organisms. Additionally, many new generation pesticide active ingredients are applied at rates 95% LESS than more toxic pesticides in the past. At a cost of sixty million dollars plus to develop and label new pesticides, the pesticide approval process is one of the most thorough processes in any industry.

4. Any chemical used to manage pests is a pesticide, whether it manages insects, weeds or diseases. Some common household chemicals such as Clorox and Lysol are pesticides that target microbes.

5. Commonly asked questions by non-professionals include:
- Why don't we just quit using pesticides?
- Aren't they poisonous?
- Don't they do more harm than good?
- Won't they harm the environment and shorten human life expectancy?

All pesticides are poisons and if applied improperly, can harm humans, other animals and the environment as a whole. Our job as IPM professionals is to use pesticides only as needed to limit economic and aesthetic loss or damage to human health caused by various pests.

Common Pests: http://www.aces.edu/pubs/docs/A/ANR0910/ANR0910.pdf

Common Insects and Diseases: http://www.aces.edu/pubs/docs/A/ANR1042/ANR1042.pdf

Common Diseases of Crape myrtle: http://www.aces.edu/pubs/docs/A/ANR1047/ANR1047.pdf

Common Diseases of Juniper: http://www.aces.edu/pubs/docs/A/ANR1173/ANR1173.pdf

Common Diseases of Holly: http://www.aces.edu/pubs/docs/A/ANR1087/ANR1087.pdf

Diseases of Pansies: http://www.aces.edu/pubs/docs/A/ANR1214/ANR1214.pdf

Phytophthora Root Rot: http://www.aces.edu/pubs/docs/A/ANR0571/ANR0571.pdf

Diseases of Leyland Cypress: http://www.aces.edu/pubs/docs/A/ANR1160/ANR1160.pdf

Diseases of Hydrangea: http://www.aces.edu/pubs/docs/A/ANR1212/ANR1212.pdf

Dogwood Diseases in Alabama: http://www.aces.edu/pubs/docs/A/ANR0551/ANR0551.pdf

Controlling White Grubs in Turf: http://www.aces.edu/pubs/docs/A/ANR0177/ANR0177.pdf

Weed Management

- **Pre-emergent herbicides —** are pesticides that limit the development of weeds in lawns and shrub beds that reproduce by seed

Most are required to be watered in to start the weed inhibition process. Existing weeds that are biennial or perennial or reproduce from bulbs or vegetative structures will not be managed well with pre-emergent herbicides and must be spot sprayed with post emergent herbicides to manage them.

- **Number of applications** – most turf programs use 3 to 4 applications of pre-emergent per year, while shrub beds may receive 2 to 3.

Newer generation pre-emergent herbicides may last as long as eight months at higher use rates, greatly cutting down on application frequency.

- **Pre-emergent herbicide targets** – any seed that is germinating in the soil may be inhibited by pre-emergent herbicides

Some seeds are more easily managed by certain herbicides.

Read the pesticide label before applying any pesticide!

Significant fines and jail time are possible if pesticides are misused.

Business Concepts

- **State Professional Services Permits** – many states require any person installing plants for a fee to have a Landscape Contractor's or "Setting of Landscape Plants" license, obtained by passing an exam and being current with yearly fees.

If you give any landscape design advice, you also need a "Landscape Design" license, in states where one is available.

Applying any fertilizers with pesticides on them, or applying pesticides such as Roundup, requires an "Ornamental and Turf Pest Control" license. Some cities are now requiring SLP and OTPS licenses before bidding on any city work.

Fines and jail time are possible if you fail to comply with the law!

- **City and county business licenses** – all businesses must have licenses in every city or county they perform work

Because each city does require separate licenses, a small contractor may be wise to try to limit work to several city areas to cut license and travel costs.

- **State Licensed General Contractor's license** – many states have laws that require contractors installing jobs over a certain dollar value to be Licensed General Contractors

You would be wise to contact your state's licensing office to find out more details.

- **Liability Insurance** – needed to protect the business from everyday problems that arise such as damage to a customer's home caused by an employee while landscaping

Most commercial contracts will require a policy with specific coverage limits.

- **Workman's Compensation Insurance** – required for companies with four or more full or part time employees during a calendar year

Even if your company has less than four employees, it may be required by contract or may be a good idea to have the insurance. Workman's Compensation Insurance provides coverage for injuries to employees that occur at work. Companies without WC insurance may be subject to penalties, fines, and civil liabilities.

- **Business Vehicle Insurance** – personal vehicle insurance may not cover an accident that occurs doing business activities

Check with your insurance agent for the coverage needed.

- **Proper payment of federal, state and FICA taxes** – it is wise to have an accountant to help you with advice about submitting the proper payroll and other taxes to government agencies

Improper or nonpayment of payroll taxes is a major problem with *penalties, interest and jail time* as possible repercussions.

- **Department of Transportation compliance** – the DOT regulates all commercial vehicles in the United States

Contractors with trucks and trailers over a certain Gross Vehicle Weight (26,001 lbs. GVW) will be required to comply with certain signage, safety, and health regulations before traveling to job sites. Contact your state's DOT to understand your responsibilities.

Landscape Math

Make sure you bring a ruler and calculator to help with the test!

Math is an essential part of your horticulture business and career. Whether you are estimating a job, reading a set of landscape plans, or working on your payroll, your math skills are critical. For this reason, expect to be asked to work ten or more problems that involve reading scale rulers, square and cubic measure, bidding jobs based on labor and production hours, and estimating fertilizer needs.

- **Reading scale rulers** – you may be asked to use a ruler to read dimensions on a landscape plan.

If the scale of a drawing is 1" = 10', a plan with a tree 5" from a house corner will become an installed tree 50' from the house in the field.

On the same plan, a shrub bed 2" x 3", will become a bed 20' x 30' installed.

If the scale is 1" = 4', a flower bed 2" x 2" will actually be 8'x8' installed.

If the scale of a drawing is 1" = 20', plants that are ¼" apart on the plan, will be 5'on center in the field.

- **Calculating actual nitrogen** content if given the fertilizer carrier analysis, and applying it to practical problems.

Fertilizers are carriers with the primary macronutrients expressed as percentages of the total weight. If your fertilizer is 20-0-10, it contains 20% nitrogen, 0% phosphorus and 10% potassium.

If the bag weighs 50 pounds, it contains 50 pounds x 20%, or 10 pounds of nitrogen or "actual" nitrogen.

In most landscape situations, you will be given specifications to apply the fertilizer in pounds actual nitrogen per 1,000 square feet.

It will take 5 pounds of 20-0-10 to give you 1 pound actual nitrogen per thousand, as 5 x 20% = 100% or 1.

1. Your soil test results call for 2 pounds of actual nitrogen per thousand square feet per year to be applied to the landscape.

> If you have an area of shrubs 20' x 100', how much 16-4-8 fertilizer is needed in a year's time?
>
> 20' x 100' = 2,000 square feet
> 2 pounds per thousand square feet x 2 = 4 pounds total actual nitrogen
> 4 pounds actual nitrogen divided by 16% or .16 = 25 pounds 16-4-8 fertilizer

2. You are going to apply 1 ½ pounds of actual nitrogen to a bermuda lawn that measures 10,000 square feet.

> If you have a fertilizer that has a 32-3-10 analysis, how much fertilizer is needed for the lawn?
>
> 1½ pounds of actual N per thousand x 10 (the amount of 1,000's in 10,000) = 15 lbs. actual N
>
> 15 pounds actual nitrogen divided by 32% or .32 = 46.875 or 47 pounds 32-3-10 fertilizer

3. How much 20-4-10 fertilizer with pre-emergent herbicide should you apply per acre if the desired actual nitrogen is 1 lb./1,000 sq. ft.?

> Please consider that *it is illegal* to apply a fertilizer with pre-emergent herbicide if you do not have a current Ornamental and Turf Pest Control license.
>
> If you are licensed, you first must know that there are **43,560 square feet per acre.**

One- pound actual N per thousand x 43.5 (the number of 1,000 sq. ft. blocks in an acre.) = 43.5 pounds actual N

43.5 pounds of actual N divided by 20% or .2 = 218 pounds 20-0-10 fertilizer

- **Calculating the number of plants** in an area after being given the on center spacing.

To give you an example, let's say you have the opportunity to install 2,000 square feet of 4" summer annuals on 12" centers for a housing development.

When planted on 12" or 1' centers you need almost 2,000 plants, after subtracting for edges, curves etc.

You do a great job and win the fall contract after bidding the new job for the same price.

The problem is that your supplier tells you that pansies need to be planted on 8" centers and you will need 2.25 *times* as many plants and you are on your way to losing a lot of money!

To help with your future work remember the following:

For an area 10' x 10', or 100 sq. ft., you need about:

1. 100 plants on 12" or 1' centers (1x or a multiplier of 1)
2. 144 plants on 10" centers (1.44x)
3. 225 plants on 8" centers (2.25x)
4. 400 plants on 6" centers (4x)
5. 900 plants on 4" centers (9x)
6. 25 plants on 2' centers
7. 11 plants on 3' centers

It's great to memorize, but better if you can work it yourself. To figure the amount of plants in a given area and on center spacing, multiply the distance in inches times that number and divide that into 144", the number of inches in a square foot.

This number can be multiplied by the square footage to come up with the needed plants.

For example, you are asked to plant 2" pots of mondograss on 8" centers in a bed 10' x 20'.

How many plants do you order from your supplier?

1. Multiply 8” x 8” = 64 square inches
2. 144” divided by 64” = 2.25
3. 2.25 x 10’ x 20’ = 450 plants

Because the customer does not think the planting is thick enough, you are asked to pull the entire bed and reinstall 6” on center. To calculate the new total number of plants:

1. Multiply 6” x 6” = 36 square inches
2. 144” divided by 36” = 4
3. 4 x 10’ x 20’ = 800 plants

There are some factors that affect how many plants you need besides spacing. Staggered or triangular patterns will require more plants than a square or rectangular pattern.

Because plants are not placed on the bed edge, you can usually discount your number somewhat to allow for that information. Additionally, some plants will be taken out to fit beds that are curved or irregular.

For a 1,000 square foot groundcover planting, your customer wants a plant quantity comparison between planting 3’ and 2’ on center spacing.

1. 3’ x 3’= 9 sq. ft. per plant
2. 1,000 sq. ft. divided by 9 = 111 plants
3. 2’ x 2’ = 4 sq. ft. per plant
4. 1,000 sq. ft. divided by 4 = 250 plants
5. 250 – 111 = 139 more plants on 2’ centers

- **Calculating square and cubic measure.**

There are 3’ x 3’ or 9 sq. ft. in a square yard of sod.

How many square yards of zoysia do you need to order for an area 25’ x 40’? Assume there is no loss when cutting.

1. 25’ x 40’ = 1,000 sq. ft.

2. 1,000 sq. ft. divided by 9 sq. ft. = 111 sq. yds.

There are 3' x 3' x 3' or 27 cubic feet in one cubic yard. How many cubic yards of soil are needed to fill a planter 10' wide x 40' long x 1' deep?

1. 10' x 40' = 400 sq. ft.
2. 400 sq. ft. x 1' deep = 400 cu. ft.
3. 400 cu. ft. divided by 27 cu. ft. = 14.8 cubic yards

Bark mulches and topdressing is applied in layers less than 1', so all depths must be given in decimal equivalents or fractions of a foot. For example:

2" of depth is 2/12 or .166 feet
3" of depth is 3/12 or .25 feet
4" of depth is 4/12 or .33 feet

How much bark mulch do you order to mulch an area 20' wide x 100' long x 3" deep?

1. 20' x 100' = 2,000 sq. ft.
2. 2,000 x .25' (3/12') = 500 cu. ft.
3. 500 cu. ft. divided by 27 cu. ft. = 18.5 cu. yds.

- **Pricing jobs based on hourly labor rates and productivity charts**

It is important to price your jobs with a keen eye on labor, as *labor is the greatest risk* to most landscape contractors.

Bid your labor in manhours, with each hour worked per laborer as one manhour.

For example, 12 hours of labor could be one man working 1 ½ days or 3 men working ½ day each.

It would not be uncommon to bid a job at $45 per hour and have confusion occur.

There probably are many companies that charge as little as $20 an hour per man because they do not understand the real cost of doing business. There are also companies that charge $45 an hour *per man* because they understand the costs of business and have overhead due to insurance, other legitimate business costs and feel they deserve a profit.

When you present an estimate to a customer, make sure they understand your billing for labor is based on *manhours or cumulative time*, not elapsed time.

You have been asked to price a small landscape job that will involve planting 300, three-gallon plants for a developer.

From past experience, you know that your crews can plant an average of 10, three-gallon shrubs per man per hour.

Your labor charge is $35 per man hour. What is the amount of the *labor bill* you will give your customer?

1. 300 three-gallon shrubs divided by the production rate of 10 per hour = 30 hours
2. 30 hours of labor x $35 per man hour = $1,050

If you send a five- man crew, how many hours will elapse before you complete the job?

1. 300, three-gallon shrubs divided by 10 = 30 hours
2. 30 hours divided by 5 crew members = 6 hours total

Landscape Safety

Safety is a very important part of your work in the landscape industry. Properly managed companies know they must provide safety training and personal protection equipment as required by state and federal law.

Company managers may find applicable laws by contacting the federal Occupational Safety Health Administration. If you do training, make sure all employees sign off on what they have learned and keep those records in their personnel file.

Safety training without signed verification is of little use in court.

Major areas of concern are as follow:

- **Back safety** – teaching your employees to lift properly, whether that means using proper mechanics, a helper or a piece of equipment is crucial

Back injuries are a major source of workman's compensation claims and can be prevented with proper training. All employees should be taught to stretch properly, and stay hydrated, before doing any heavy lifting.

When lifting heavy objects, squat closely to the object and lift using the large muscles in the legs. Lifting with locked legs and a bent waist results in **10x the force on your back** as compared to using proper lifting techniques.

- **Hydration** – doing heavy or hot work without proper fluid intake may create more problems with heat stress, heart irregularities and muscle weakness

Your employees should avoid caffeinated drinks that act as diuretics or "fluid losers." Caffeine and high sugar drinks also put much more pressure on your heart and general metabolism, creating greater stress. Diluted sports drinks, water, and some fruit juices, combined with proper eating habits make the most sense.

If you are diabetic or have other health problems, you should talk to your doctor before doing heavy outdoor work.

- **Eye safety** – mowers and string trimmers can create projectiles that travel at 200 mph

Employees working with, or around others using power equipment, should wear safety goggles, long pants and sleeves, gloves, hearing protection and safety boots.

- **Hearing safety** – noises above 85 decibels can create permanent hearing loss in your employees

Power tools such as blowers, string trimmers, mowers, tractors, etc. can all cause damage after use as their decibel rating often exceeds 85 to100 decibels. "Ringing in the ears" is a good gauge that hearing loss has occurred. Disposable earplugs and earmuffs are recommended for employees who use power equipment. In many cases, OSHA regulations will mandate employer supplied PPE!

Many ground crews are swapping over to battery operated handheld equipment to lessen hearing damage and pollution concerns.

- **Mower safety –** riding and push mowers are common causes of accidents in landscape management work

Mowers turning over, cutting off toes or fingers, projectiles, and burns from mufflers are common issues. As with all equipment, you and your employees must read and follow the manufacturer's safety manual.

Always push; never pull a "push mower." Avoid cutting up and down slopes with walk behind mowers. When using a riding mower, avoid cutting across the slope. Most manufacturers will ask you to ride the mower up and down the slope to avoid flipping over.

Most mowing equipment should not be used on slopes greater than 30%. Do not ask an employee to do any activity prohibited by the manual.

There is a nice collection of equipment safety and use videos on the Portal for your information and study support.

- **Driving safety** – employees must have a valid driver's license, and not be taking medications or substances that affect their driving

Aggressive driving with a crew and equipment on board is a recipe for disaster. Drivers should be expected to check oil and tires before driving to a work site. Tires that are under-inflated are more likely to explode than those that are properly inflated.

Companies that don't encourage driving safety by replacing worn tires and brakes are creating a safety culture that will lead to accidents and lawsuits. DOT inspections will become more frequent and carry greater penalties in the future.

Conduct frequent, verifiable safety training and encourage all your employees to make safety Job #1!

Other reference materials:

Annuals: http://www.aces.edu/pubs/docs/A/ANR0184/ANR0184.pdf

Alabama Gardener's Calendar: http://www.aces.edu/pubs/docs/A/ANR0047/ANR0047.pdf

Residential Landscape Design: http://www.aces.edu/pubs/docs/A/ANR0813/ANR0813.pdf

Finally, the exam for students and employees may require they demonstrate their practical knowledge of the following skills to pass the certification exam:

Practical Skills Content

1. Pruning Cuts, Timing and Targets

2. Tree Limb Removal Process

3. Planting Process for B&B, Container, and Bare root plants

4. Soil Preparation

5. Plant Spacing, Square, and Cubic Measurement

6. Fertilizer and Lime Calibration and Application

7. Turf Mowing Heights and Mower Adjustment

8. Basic Pest Identification

9. Basic Landscape Plant Identification

11. Pesticide Application with a Pump Sprayer

12. Landscape Safety

Sample Exam

Green Industry Web Portal Sample Landscape Management Certification Exam

1. Weeds can be perennials, biennials or _____.

2. For most landscapes with turf, one pre-emergent and two post-emergent herbicide applications will manage even heavy weed pressure. True or False? _____

3. Small landscape management companies making less than $100,000 per year do not need business or state pesticide licenses. True or False? _____

4. Leaves are able to turn carbon dioxide and water, through photosynthesis, into _____.

5. Ants will move pests from one tree to another. True or False? _____

6. What type of pesticide is Roundup? _____

7. Shearing is best practiced on large leafed shrubs. True or False? _____

8. The best way to manage foliar disease such as rose black spot or crepe myrtle powdery mildew is to do what? _____

9. Which turf handles drought the best? _____

   Zoysia Bermuda Centipede St. Augustine

10. _____ and oils may be used to kill pests, without using traditional pesticides.

11. Soils with low acid have a high or low pH? _____

12. Once a limb is removed from a tree, the wound should be painted with asphalt-based pruning paint until it heals. True or False? _____

13. If the mower blade is set to 2", how tall can the grass grow before you need to mow? _____ 2” 2.5” 3” 3.5”

14. Watering every other day will help prevent weeds in turf. True or False? _____

15. What group of insects enters and kills trees that have been weakened by drought and mechanical injuries? _____

16. To apply 2 pounds actual N to a lawn per 1,000 square feet, how much 20-2-10 would be needed? _____ 10 lbs. 8 lbs. 5 lbs. 4 lbs. 3 lbs.

17. If you have two pesticides, "A" with an LD_{50} of 50 and "B" with an LD_{50} of 750, which is more toxic? ____

18. Pruning cuts made inside the shrub canopy, at the ground level, to open up the plant would be known as _____.

heading back pinching leader removal thinning

19. Before removing the blade from a lawnmower for sharpening, what safety precaution should you take? _____

20. Bending from the waist with legs locked increases the pressure on the lower back about twice compared to lifting with a straight back and bent knee. True or False? _____

21. Pesticide-rated gloves are only required for insecticides. True or False? _____

22. Acute pesticide toxicity is the result of several months of pesticide use. True or False? _____

23. The federal agency responsible for pesticide regulation and oversight in the United States is known as the EPA. True or False? _____

24. The most important mineral nutrient for plant growth is _____.

25. _____ and _____ are two nutrients that will "green up" plants.

26. Shrubs that bloom in August are best pruned before growth occurs in the spring. True or False? _____

27. Examples of spring flowering plants include forsythia and abelia. True or False? _____

28. To properly remove a large limb from a tree, the best process includes how many saw cuts?
_____ a.1 b. 2 c. 3 d. 4

29. Long-handled loppers provide the highest quality cut for trees like Japanese maple and dogwood. True or False? _____

30. Pulverizing or tilling planting beds thoroughly may be more important to landscape success than the addition of nitrogen fertilizers at planting. True or False? _____

31._____soils in Alabama are usually reddish in color and often drain poorly but may contain lots of native nutrition.

32. Soils in the Southeast may have less than 1% organic matter by volume. True or False?
_____

33. The Department of Transportation may require vehicles over a certain gross vehicle weight to comply with a series of regulations before work begins. True or False? _____

34. Three inch caliper ball and burlap trees often lose _____% of their root system in transplanting? a.10% b. 25% c. 50% d. 75% plus

35. The major negative encountered using containerized shrubs in the landscape is: _____

a. high cost b. pot bound or girdling roots c. weeds found in the bark soil

d. there are no issues with container grown shrubs

36. Planting holes for 15 gallon trees should be about twice the diameter of the root ball and how deep?
a. Half again as deep b. 5" deeper c. Less deep than the root ball
b. None of the above

37. Oaks have opposite or alternate leaves? _____

38. Approximately how much sod would you need to install a turf area that is 50' x 70'?

a. 150 yd^2 b. 255 yd^2 c. 325 yd^2 d. 388 yd^2

39. Conifers include cedars, pines, and _____.

40. Shade-loving groundcovers include English Ivy, _____and _____.

41. Two ways that trees may stop wounds from enlarging too far are the natural barriers known as rings and _____.

42. When parking a truck and trailer to unload equipment, it is best to park so you do not have to do what to move to another site? _____

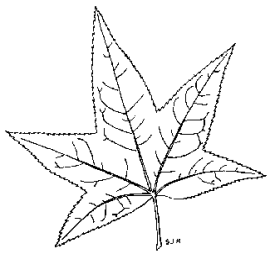
43. In almost all cases, full-strength sports drinks like Gatorade are the best way to combat heat related illnesses. True or False? _____

44. Which of these flowering shrubs would be pruned right after bloom? Circle all the correct answers.

a. azalea b. crape myrtle c. butterfly bush d. forsythia e. abelia f. southern magnolia

45. This leaf is best described as: _____

a. compound b. simple c. alternate d. opposite e. none of the above



46. Mowing turf at 1" is one of the best ways to help it spread and to manage weeds.

True or False? _____

47. When mowing a steep slope with a ride-on mower, it is best to cut from side to side.

True or False? _____

48. Your company charges $35 per hour for pruning and general landscape management. You have a two-man crew working from 8:30 – 11:30 AM. How much should you bill for labor?

a. $105 b. $140 c. $210 d. 245

49. The specifications for the property you are managing calls for 2 pounds of actual nitrogen per 1,000 square feet per year split into two applications of one-pound each. If you are using a 25-2-8 fertilizer how much is needed for the first application to a 5,000 square foot property?

50. You are installing 2" pots of Asiatic jasmine on 1' centers to an area 25' x 40'. How many plants should be ordered?

51. Hearing damage begins to occur when the decibel rating reaches how many decibels?

a. 25 b. 65 c. 85 d. 130

52. When back-filling a parking lot island with 1' of soil, how many cubic yards should be delivered if the island is 500 square feet?

a. 18.5 yd^3 b. 25 yd^3 c. 35 yd^3 d. 46.5 yd^3

53. Common household products such as Clorox and Lysol are actually pesticides.

True or False? _____

54. Which is the best month to core aerify a Bermuda lawn?

a. January b. late- February c. early- March d. late-April

55. Groundcovers that will do well in the shade include which of the following?

a. mondograss b. pachysandra c. ajuga d. cotoneaster e. juniper

Identify the following provided samples:

56._____

57._____

58._____

59._____

60._____

61._____

62._____

Bonus: Show work for partial credit!!

You have been asked to apply 100 pounds of 32-3-10 fertilizer to the front of a customer's home. How many pounds of potassium are you applying?

Contributing entities include:

Colleges and Universities: Auburn, Clemson, North Carolina State, Butler, Georgia, Virginia Tech, Arizona State, Tennessee, Dr. Ed Gilman, Florida, Oregon State, Mississippi State, Minnesota, Colorado State, Oregon State

State Extension Systems: Alabama, Florida, Arkansas, Georgia, South Carolina, Virginia, Oregon, Mississippi, Tennessee, Minnesota, Colorado, Iowa, Kansas

Other: Urban Forestry South, Tekura Schools, New Zealand, InfoVisuals,