The Way Trees Work – How to Help

TREE CITY USA® BULLETIN

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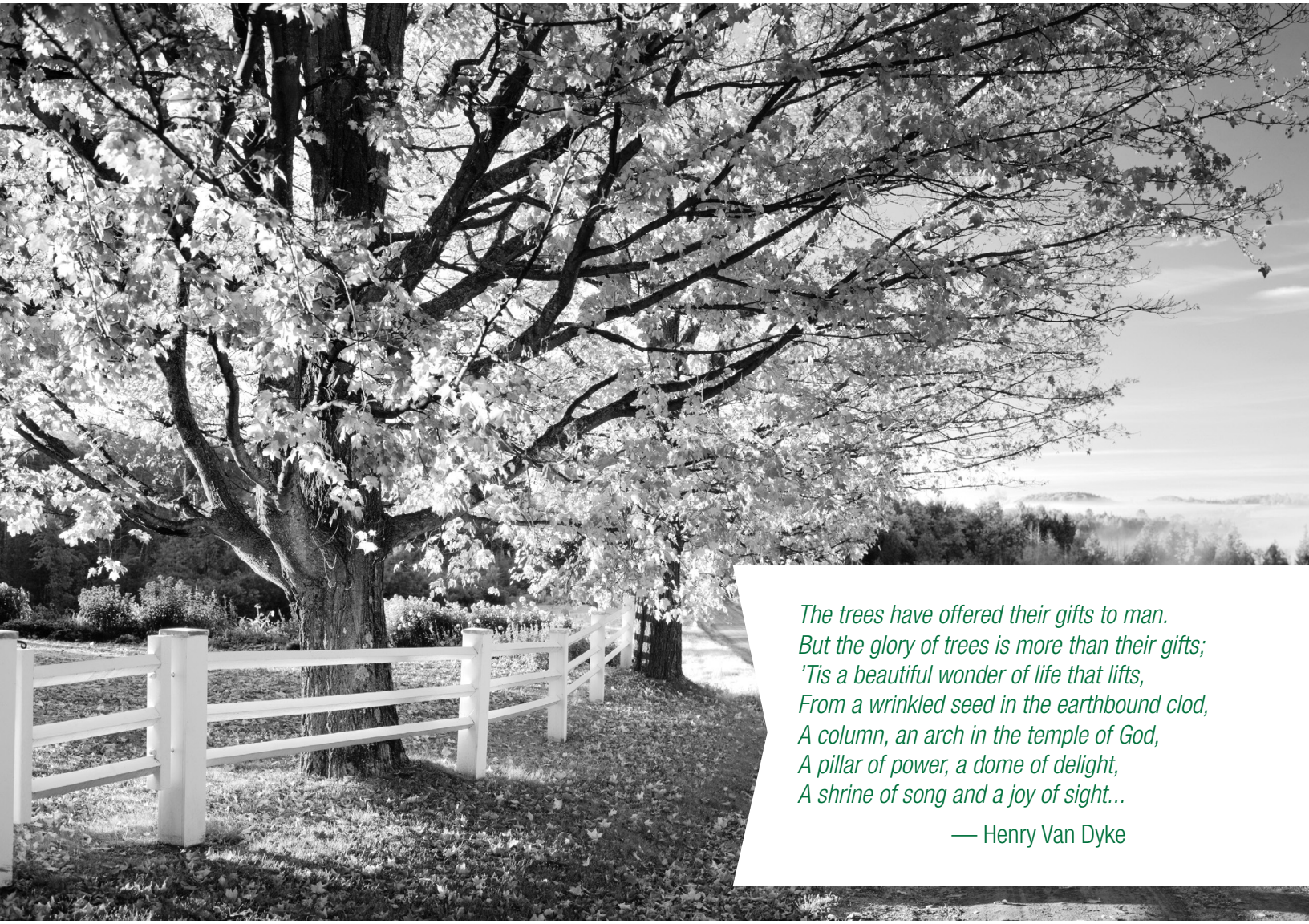

The trees have offered their gifts to man.
But the glory of trees is more than their gifts;
'Tis a beautiful wonder of life that lifts,
From a wrinkled seed in the earthbound clod,
A column, an arch in the temple of God,
A pillar of power, a dome of delight,
A shrine of song and a joy of sight...

— Henry Van Dyke

How trees live and grow is a fascinating subject that some people pursue for a lifetime. But by knowing even a few basics, it is possible to better understand why some of the things we do to trees help their growth while others hinder it.

Not long ago a consulting forester wrote to the Arbor Day Foundation urging that an issue of Tree City USA Bulletin be devoted to the basics of tree growth. The forester wrote, "It continually surprises me just how little most people know about how a tree grows and functions."

This bulletin is in response to that need. It is an attempt at the bewildering task of condensing into eight pages material that easily fills scores of textbooks and scientific journals. But as impossible as that may be, it is important to know some basic functions, as the forester suggests. To many people, this is fundamental knowledge, but to others it is completely foreign. Perhaps more importantly, in the pages that follow is an attempt to show how the actions and practices of humans are related to the needs of the tree.

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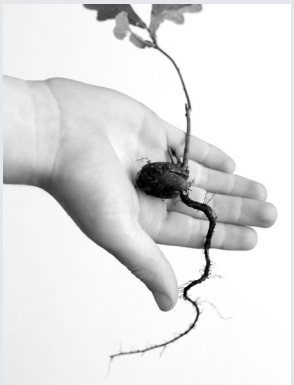
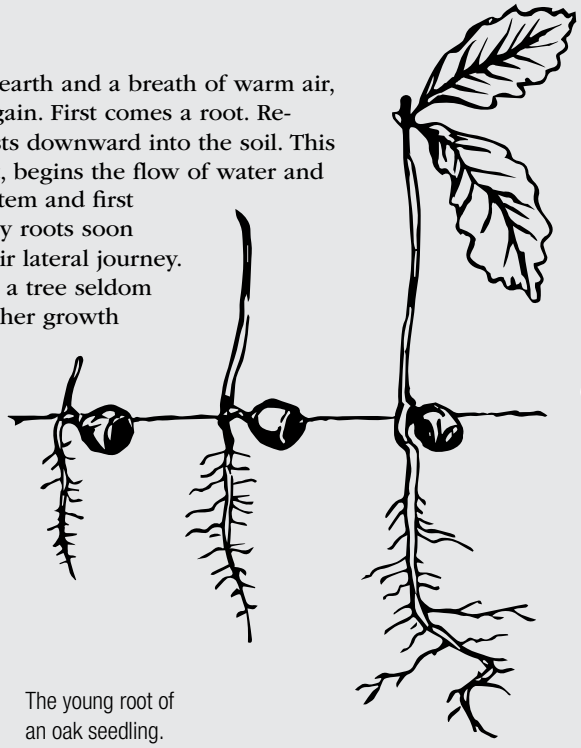
Roots

Roots are a tree's lifeline. They anchor against the wind, absorb water, and wrest vital elements from the minerals and organic debris we call soil. Roots are essential not only to the health of trees, but to the safety of humans near trees. But as important as they are, roots are the least understood and appreciated part of a tree.

NEW LIFE TAKES ROOT

With the touch of good earth and a breath of warm air, the miracle of life begins again. First comes a root. Responding to gravity, it thrusts downward into the soil. This tiny thread, or primary root, begins the flow of water and nutrients upward into the stem and first leaves of the tree. Secondary roots soon sprout and head out on their lateral journey. So begins the side of life in a tree seldom seen, but upon which all other growth depends.





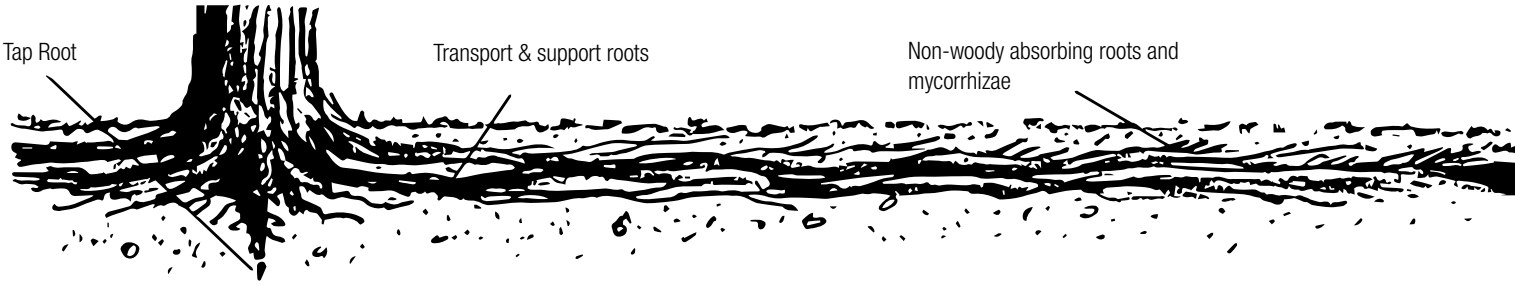
The young root of an oak seedling.

WHERE DO THE ROOTS GO?

The record-holder for root depth is probably the lowly one-seed juniper. Its roots have been found in mines more than 200 feet beneath the surface of the semiarid Southern Rockies! Determining a champion for radial spread is more difficult, but distances of 100 feet or more are common for many species.

Both depth and spread are controlled to some extent by genetics, just like the shape of the crown. However, the more important limiting factors are subsurface barriers such as solid rock, compacted soil, foundation walls, excessive moisture, or lack of oxygen. Roots grow where the most favorable conditions exist. In urban soils, this is generally near the surface where moisture levels are best, oxygen is available, and fertilizers are sometimes spread to benefit grass.

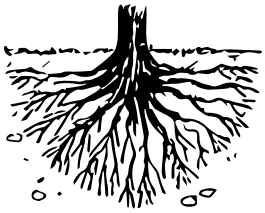
IMPORTANT ROOT FEATURES AND FUNCTIONS



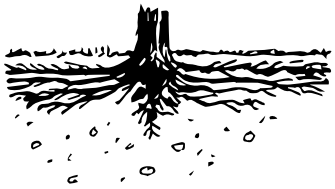
TAP ROOT This downward growing root is the first, or primary root. In most trees it is choked out by secondary roots within a few years or diverted by obstacles. In some species, however (like the oaks and pecans), it persists and makes transplanting difficult.

TRANSPORT AND SUPPORT ROOTS These long, rope-like roots transport water and nutrients from the absorbing roots to the above ground portions of a tree. They are relatively few in number and serve like arterial streets in a city. These roots are woody, expand in diameter each year, and keep the tree from falling over. They also serve as a winter storehouse for sugars (in the form of starch) that are produced in the leaves and provide energy for growth and other life functions.

ABSORBING ROOTS are soft and non-woody. They consist of two kinds that intimately intermingle. Both are necessary for extracting water and 14 essential elements from the soil. First there are the tiny root hairs; the others are attached strands of beneficial fungi that fuse with the roots to form symbiotic organs called mycorrhizae. In most healthy trees, mycorrhizae will be far more numerous than root hairs,

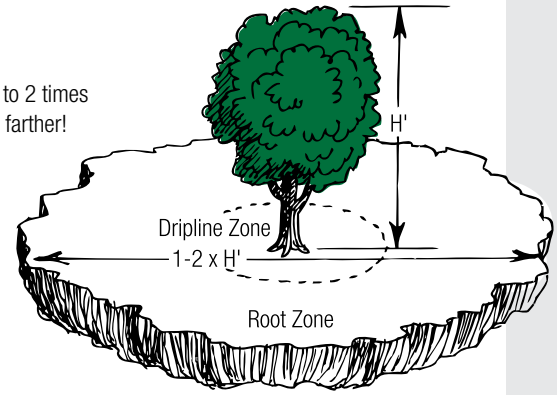


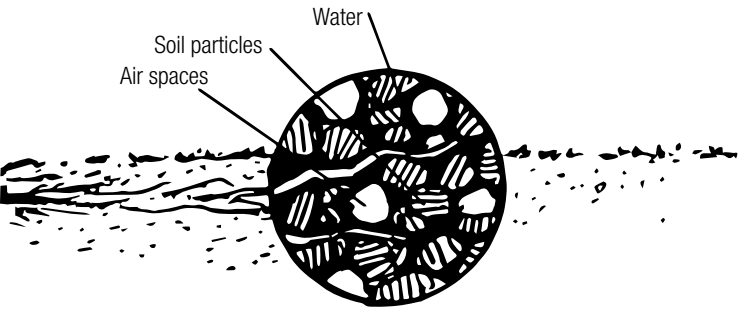
RARELY TRUE: This is how many people envision a tree's root system. While a few species do have deep tap roots, most do not. Nor do the roots of a tree mirror its crown. This notion is more artistic than accurate.



MORE COMMON: Roots spread to where soil conditions provide elements and moisture, which is usually near the surface. About 85 percent of a tree's roots are within the top 18" of soil.

Roots typically spread up to 2 times the height of a tree — or farther! However, the essential mass of roots is usually considered to be within the "dripline," the area underneath a tree's branches.





greatly multiplying the tree's ability to supply itself with adequate water and elements.

THE ROOT - SOIL INTERFACE Root elongation occurs at the tip of each root in a zone of active cell division called the growing point. This is located just behind another zone at the very tip of the root (root cap) where disintegrating cells produce a slightly slimy lubricant. Root tips and absorbing roots grow their way through pores in the soil. These little spaces also allow water and air to move through the soil and become available to the roots.

HOW TO HELP

Protecting roots and providing a good environment for their growth is the foremost key to tree care. Here are some ways that help.

1. AT PLANTING TIME...

Good planting techniques include: (1) carefully removing wrapping and binding materials, but without breaking the soil loose from the roots, and (2) loosening the soil beyond the planting hole. This will allow roots to expand easily and contribute more quickly to tree growth.

2. DON'T CUT ROOTS

Severed roots hamper growth, give disease an entry point, and threaten a tree's stability. Where trees are established, use the many techniques available to avoid cutting roots during construction, street or curb replacement, utility or irrigation installation, or other activities that require digging. More details about cutting roots can be found in Bulletins No. 3 and No. 7. See page 8 for information about obtaining past bulletins.

3. IF ROOTS ARE SEVERED...

When it is not possible to avoid severing roots larger than 1 to 2 inches in diameter, use a clean, sharp saw to make the cut. If the root has been crushed or torn, make a cut between the damage and the tree trunk. Also cut off any crushed roots when planting a tree. New roots will sprout more readily from a smooth cut, and rot fungi are less likely to successfully invade the tree.

4. PREVENT COMPACTION

During construction, roots must be protected from compaction. Compaction by feet or vehicles closes the soil pores and deprives roots of oxygen, moisture, and growing space. A 3- to 4-inch layer of wood chips can prevent compaction as well as add mycorrhizae to urban soil. During construction activities, other efforts are needed such as deeper mulch or steel plate "bridges." See Bulletin No. 7.

5. CONTROL WATER AND CHEMICALS

Managing trees and turf (grass) together can be tricky. Many arborists have observed that more trees "drown" than die of drought. The villain — automatic sprinklers! Similarly, while weed control chemicals help produce a lawn of pure grass, they may also be absorbed by tree roots. The way out of this dilemma is to water lawns only when needed and to spot spray weeds instead of broadcasting herbicides (including those mixed into fertilizer).

Trunk and Branches

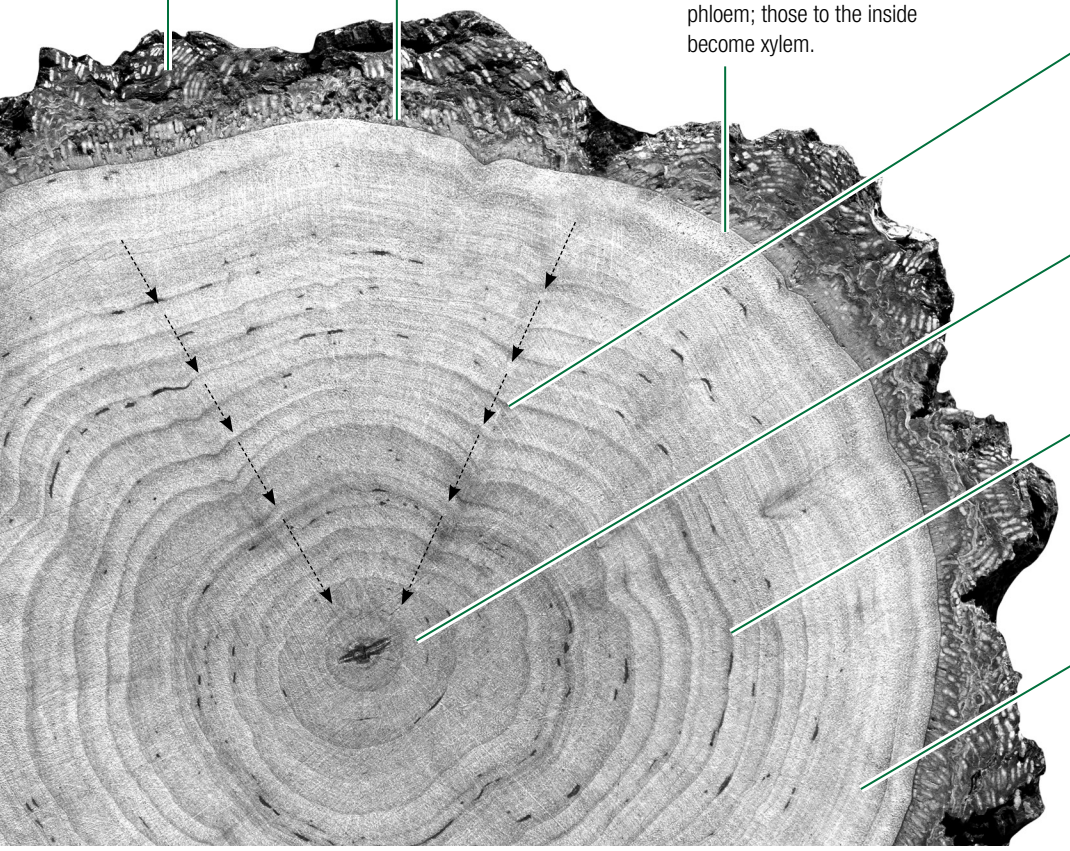
Visually, trunk and branches define the tree. It is the shape we recognize and a main reason we plant one species instead of another. But in all trees, this woody structure has function as well as shape. It is like a busy avenue connecting food-manufacturing factories (leaves) with the receiving dock and warehouse (roots). Although much of the wood consists of dead cells that do little more than provide support, other cell layers near the periphery of the tree are responsible for new growth, while still others transport materials up and down the tree. All make the difference between life and death.

BARK
The protective outer layer of woody tissue that is the tree's equivalent of skin.

PHLOEM
Tissue that lies just inside the bark (and often called inner bark). Its role is to transport food (sugars) from the leaves to the roots and to other living cells throughout the tree.

CAMBIUM
A microscopic zone of cells that specialize in cell division. From this layer, and only this layer, new cells are produced that result in diameter growth. Cells produced to the outside of the layer become phloem; those to the inside become xylem.

THE CROSS SECTION SHOWN HERE is representative of trees like conifers and broadleaf species, with the features usually more visible in the latter. Palm trees are quite different and are not shown.



WOODY RAY
Specialized cells radiate through the tree like spokes of a wheel. This living tissue enables water and nutrients from the xylem and phloem to move to interior parts of the tree.

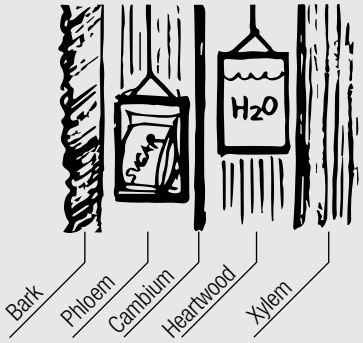
HEARTWOOD
Heartwood is xylem that has ceased to function and provides the supportive inner core of the tree. It is the noticably darker portion of the trunk.

ANNUAL RING
A close-up of a hardwood cross section would reveal how xylem cells decrease in size as the summer progresses. The smaller, more densely packed cells added late in the season (latewood) make up the dark part of an annual ring.

XYLEM (SAPWOOD)
These are the water conducting cells that bring up moisture from the roots to all parts of the tree. It is lighter in color than heartwood. In spring, it is this part of the tree from which maple sap is collected.

HOW TRANSPORTATION TAKES PLACE

Sugars manufactured in the leaves during photosynthesis enter phloem sieve tubes. So does some surrounding water. When the cell walls can no longer expand, the solution is "squeezed" from one sieve tube (cell) to the next. Eventually the material reaches the roots for winter storage.

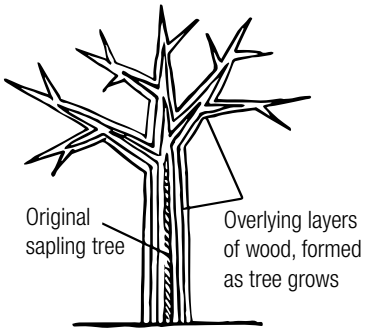


GOING UP! Water and nutrients rise to great heights thanks to the property of cohesion. Water molecules tend to cling to each other, like the beads on a water glass. In the narrow cells of xylem, a "rope" of water is formed that adheres to the cell walls. As the tree's leaves give off water during transpiration, the water "rope" is pulled upward.

AN AMAZING APPARATUS

Each year a new layer is added to a tree and the trunk expands in diameter. Note: Tree limbs do not move upward as the tree expands in size.

A tree is basically a series of woody cones, each one laid over the preceding one. Life in the tree is sustained by a complex network of cells, including some that can move water and nutrients hundreds of feet up and down the tree.



CODIT: A MODEL OF COMPARTMENTALIZATION OF DECAY IN TREES

When fungi invade a tree, they do not spread at will or there would soon be no trees! According to the late international tree expert Dr. Alex Shigo, trees have two important features that usually wall off fungi that enter at points of wounding. One is the compartmentalized structure of trees. The other is a chemical barrier produced around the edges of the invading pathogens. When any of these lines of defense fail, the decay continues its spread.

WALL 2 is at the earliest cells of the growth ring just to the inside of the injury. This limits inward spread.

WALL 1 is where the tree "plugs" vascular tubes above and below the decay to stop vertical spread.

WALL 3 is at the rays, limiting lateral spread.

Area of decay caused by wound.

WALL 4, the strongest, is at the new growth ring that forms after the injury.

Annual rings reveal the secrets of a tree's past. Favorable weather may show up as wider rings; a gradual narrowing from year to year may be the result of a losing struggle for sunlight or the sign of some other adverse condition. The combination of lighter earlywood and darker latewood comprises one year's growth. *Note: When counting rings in a stump to age a tree, be sure to add a few years to account for growth to the height where you are counting.*

HOW TO HELP

1. REMOVE TREE WRAP

Cells in the bark of many young trees contain chlorophyll. Like leaves, these cells manufacture sugars that energize the tree and help it recover from transplanting shock. This is one reason why it is recommended that tree wrap be removed once the tree is planted in its new location unless sunscald is a problem locally.

2. REMOVE TREE STAKES

As a tree's diameter increases, wires from tree stakes, clothes lines, fences, play houses, or other devices can constrict the phloem and shut off the flow of sugars and water. This will weaken and eventually kill the tree. Remove tree stakes after one or two growing seasons and keep trees free of other wires, chains, cables or nylon ropes.

3. PROTECT DURING CONSTRUCTION

Any tear or gouge in bark permanently destroys the cambium in that area and interrupts transport of nutrients through the phloem. It also provides an entry point for decay organisms. When machinery will be working around trees, protect the bark with old tires, hay bales, or snow fence — or fence off the entire area around the tree. And protect trees from nails, screws, climbing spikes and anything else that punctures the bark.

4. PROTECT FROM LAWNMOWERS

Use mulch to keep lawnmowers and weed cutters from scraping, cutting, or banging against the base of the tree.

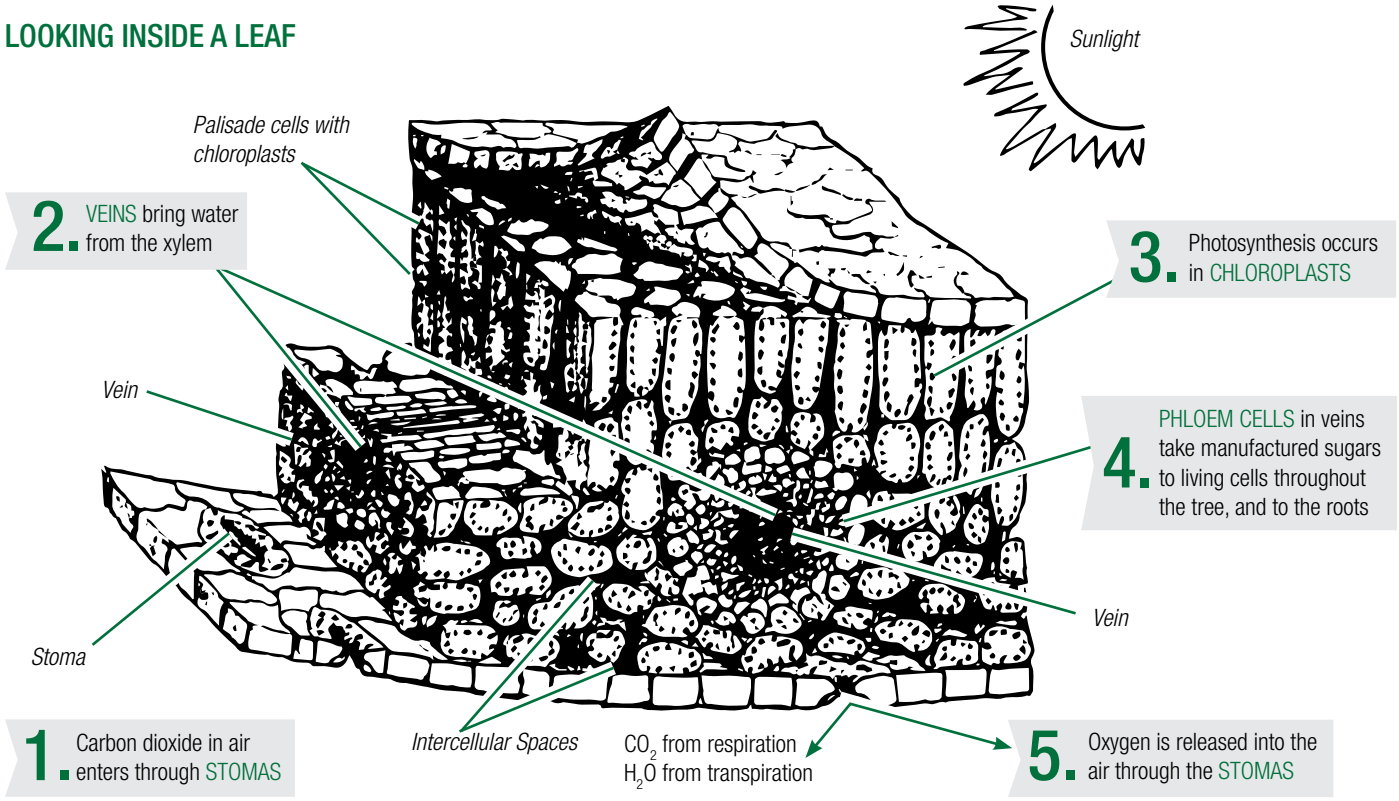
5. PRUNE PROPERLY

When you prune, cut as shown in Bulletins No. 1 and No. 2. Cutting just outside the branch bark ridge and collar allows the tree to use its natural defense system to keep out invading fungi (decay organisms).

Leaves

Leaves provide the shade of summer, the cooling effect of water pumped into the air, and the oxygen we breathe. In fall they restore elements to the soil and improve its spongy structure. Leaves are also the food factories in a tree. Inside the thin, green blades or needles — each shaped according to the genes of its species — the sun's energy is trapped and stored in chemical compounds that are then used throughout the tree to sustain life.

LOOKING INSIDE A LEAF



PHOTOSYNTHESIS

Photosynthesis is a miracle of life. It is a tree's ability to convert carbon dioxide and water into oxygen and food for the tree. Sunlight is also an essential part of the process.

$$CO_2 + H_2O + \text{SUNLIGHT} \rightarrow O_2 + \text{SUGARS}$$

RESPIRATION

Respiration is the way a tree unlocks the sun's energy from the sugars (or their stored form, starch). The bonds that hold together chains of carbon, hydrogen and oxygen molecules are broken, releasing energy to power the various biological processes within the tree. Carbon dioxide and water are given off. In a healthy tree, photosynthesis and the production of energy sources exceed the rate of respiration.

TRANSPIRATION

Water from leaves evaporates and cools the leaf. As the water exits through stomas, a "pull" is created that draws more water up from the roots through the xylem. Guard cells around the stomas open and close to regulate the flow according to air temperature and humidity. One result is protection against too much water loss on hot days.

Trees in the Urban Forest

TREES IN THE URBAN ECOSYSTEM

It is easy to become so entranced with individual trees that we forget that each tree is part of a larger ecological system. At the micro-scale, every tree is host to an astonishing array of animal life — from bees and tree frogs to squirrels and song birds. Trees play an important role in the web of life and the more we look into this, the more we can appreciate just how essential each tree is in its place.

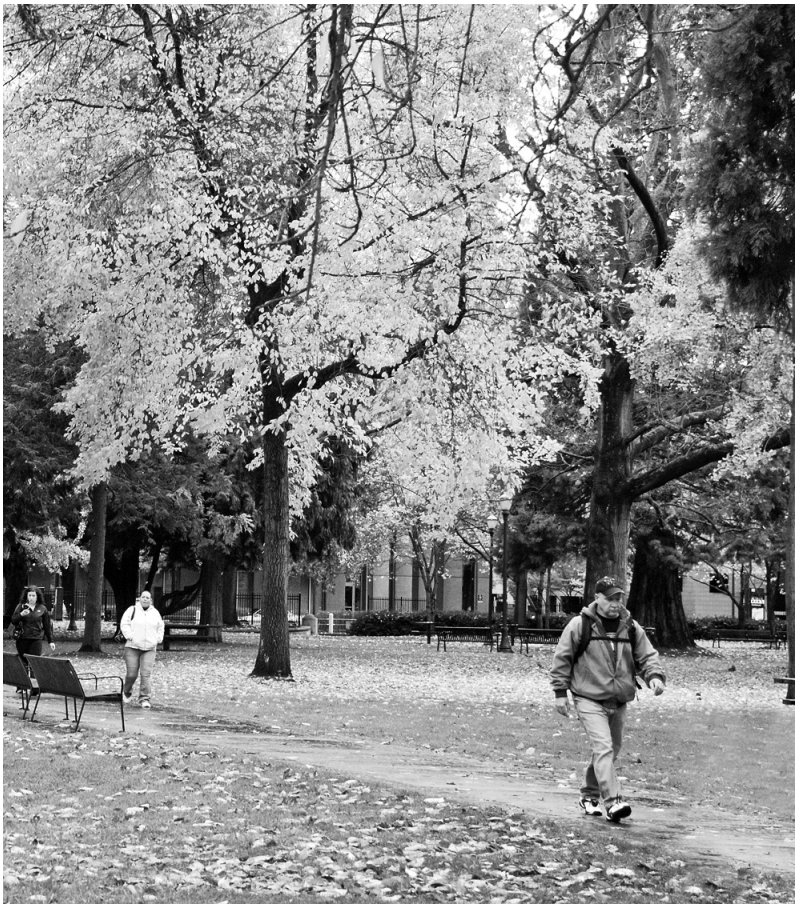
At the macro-level, urban foresters urge that we advance our thinking from "community forest" to "community ecosystem." With the advent of Geographic Information Systems (GIS) and their ability to computerize maps and "layers" of spatial features (underground utilities, streets, overhead lines, trees, etc.), it is helpful to view trees as one of the important layers in the community infrastructure.

Innovative planning and management can also be aided by thinking of trees as key elements in the cycles that sustain life:

THE AIR CYCLE Trees produce oxygen, remove carbon and air impurities, and — through shade — reduce the need for new energy production facilities, many of which contribute to the rising levels of atmospheric carbon dioxide.

THE WATER CYCLE Water released by transpiration cools the air and again becomes available to form precipitation. Trees also break the force of rain, moderate runoff, and hold soil in place on hillsides.

THE NUTRIENT CYCLE Leaves, when left in place or composted and used as mulch, restore elements to the soil and improve soil structure.



Individual trees are marvelous and important, but when added together they can be seen as part of an even greater urban ecosystem. The contributions of trees are both aesthetic and practical.

HOW TO HELP

1. ADEQUATE SUNLIGHT

Sun provides the energy to fuel systems that keep a tree alive and well. Each tree species has a specific requirement for the amount of sunlight it needs. When planting, consider the new tree's shade tolerance (shown in many reference books; or ask the nursery operator) and make sure the species and planting site are well matched. In older trees, maintain adequate growing space for shade intolerant species.

2. PRUNE SPARINGLY

As a general rule, it is helpful to leave as many branches on a tree as possible, especially after transplanting. This is because leaves manufacture the food needed to produce new roots — the most important need for a tree to establish itself in a new location. Prune only broken or rubbing limbs the first year. In older trees, "thinning" the crown is usually not necessary. Remember: the more leaves, the more food for tree vitality.

3. FERTILIZE WHEN NECESSARY

If one of the 14 essential elements is missing or deficient in the soil, tree growth will suffer. The deficiency usually shows up in yellowish or small leaves and short twig elongation. Nitrogen is the most commonly deficient element. Before you fertilize, a certified arborist should be consulted for an inspection and possibly a soil analysis. Arborists are also best qualified to apply fertilizer in the most effective form (e.g. granular or liquid) and dosage.

4. PROTECT FROM SALT

Keep de-icing salt off leaves and the soil around trees. On leaves or when it comes into contact with roots by seeping through the soil, salt draws water out of living cells, eventually depriving leaves of the water they need for photosynthesis.

Think of the Next Generation

Most readers of this bulletin will fully appreciate the wonder of trees and the benefits they provide. Young people today do not necessarily have this knowledge or appreciation. Teaching children and young adults about how trees function can be a first step toward helping them to know how to maintain trees. It is also an important foundation for stewardship of the urban forest later in their lives.

Nature Explore, a collaborative program of the Arbor Day Foundation and Dimensions Educational Research Foundation, has been designed to address that foundation for stewardship by introducing young children to nature. You can learn more at **natureexplore.org**. For older students, trees can be included in class lessons and discussions other than biology. For example, math can include calculations about size, volume, weight or the production of eco-services such as the production of oxygen or how much energy is conserved by shading. English can include a look at poets and authors who have made trees an important part of their work.

Stewardship of trees in the future depends on what adults do today. Teaching the next generation about trees is an appropriate role for tree boards as well as teachers, church or scout leaders, and others who more routinely work with youth.

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