Understanding Forestry Concepts: A Forest Ecology Series for Loggers, Landowners and Foresters

UNIT SIX

TREE PARTS AND FUNCTIONS

D. O. Lantagne, D. I. Dickmann, C. R. Blinn

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Introduction

This bulletin series is designed to introduce information that loggers, landowners and foresters should know to properly manage forest lands while understanding how forest systems work and interact so that long-term forest productivity is maintained. These bulletins are not an exhaustive discussion of important forest ecology topics. Instead, they are a brief introduction to the depth and breadth of knowledge that is necessary to manage forest stands properly. This sixth bulletin provides a general review of tree structure and physiology that is important to know in maintaining a productive and healthy forest.

The primary parts of a tree are the leaves, branches, stems and roots (8). Each of these components plays an important role in the growth and development of the tree. It is easy to see that leaves, stems and branches vary in size, shape and orientation among tree species. Much less obvious, but no less distinct, is the variation in shape, size and location in the soil of root systems (4).

Given the variations among plants, including tree species, the basic processes of plant life are still similar. For example, photosynthesis occurs in all leaves, regardless of size or shape. The act of photosynthesis combines the energy from sunlight with carbon dioxide and water to make sugar and give off oxygen (8). The sugar product is converted into more complex sugars (called carbohydrates) that are used to produce wood, more leaves and all other parts of the tree (8). Therefore, sugar production by photosynthesis is the basis for all tree growth. The better the site quality and the healthier the tree, the higher the production of sugar from photosynthesis. This higher production of sugar normally results in enhanced tree growth in the form of greater stem diameter and height (Fig. 1).

When a forest is thinned, the remaining trees have more room for crown and root growth and also more access to water, light and nutrients (5). This combination normally results in an increased rate of photosynthesis, leading to an increased diameter growth rate (reduction in the number of annual rings per inch of growth). This "thinning response" often lasts 5 to 10 years; the longer period is associated typically with sites that are less productive or where larger openings were made in the canopy (5). However, removing too many trees from the main overstory canopy can leave only slower growing trees or holes that are too large for remaining trees to close rapidly. The results can be an invasion of understory plants that restrict preferred forest regeneration and the loss of potential growth from having too few trees remaining on the site (5).

Root damage to remaining trees is another factor to consider during the harvest operation. Harvest operations that severely damage roots of remaining trees also will restrict growth response by reducing the ability of the tree to absorb water and nutrients. It may also lead to increased rot within the remaining trees. In addition, widespread equipment traffic on the site during harvest may lead to increased soil compaction which can cause decreased root development or root mortality.

Roots serve three major functions: anchorage, collection (e.g., water and nutrients) and storage (8). Roots are responsible for holding a tree upright and typically extend in two directions, horizontally and vertically. The majority of tree roots (approximately 80 percent) are located in the upper six inches of soil where they absorb nutrients released from decomposing organic matter (dead plants and animals) and water (6).

Roots in the surface soil can be damaged easily by equipment traffic if the harvesting job is not planned and conducted properly. Consider the fact that tree roots are not restricted to growing in the soil area under the crown, but extend outward to compete with other trees (6). For a rule of thumb, expect tree roots to extend outward from the stem 1.5 to 2 times total tree height. As an example, for a tree that is 50 feet tall, tree roots will extend outward about 75 to 100 feet away. Under certain soil conditions, such as on sandy sites, tree roots can extend further (6).

A well-designed road and skid trail layout, a felling pattern that is designed to utilize the road and trail network, avoiding rutting and soil compaction, and general care during harvesting are the keys to minimizing root damage.

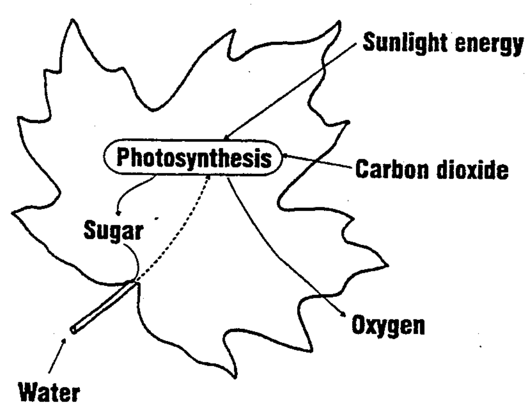

Figure 1: The process of photosynthesis combines the energy from sunlight with carbon dioxide and water to make sugar and to produce oxygen. The sugar product is converted to more complex sugars (carbohydrates) that are used to produce wood, more leaves, and all other parts of the tree. The more photosynthesis that occurs in leaves of a tree, the more sugar is produced and available for tree growth.

Although some root damage will occur, proper harvesting practices can result in improved growing conditions (increased light, water and nutrients) for remaining trees (5). The improved growing conditions are usually sufficient to offset losses associated with limited root damage.

Although tree roots are quite adaptable to site conditions (4), certain combinations of wet soils, shallow root systems and silvicultural practice (thinning) on these site types can create conditions for significant forest loss after harvest due to blowdown (5). Care must be taken to evaluate sites before the harvest to insure that the layout of the harvesting operation minimizes the amount of blowdown and breakage in the thinned forest after harvesting is completed. Also keep in mind that rooting habits vary with tree species. This fact also may influence harvest operations.

Stems are probably the next most susceptible tree part damaged during harvesting operations. Tree stems are responsible for carrying water, nutrients and sugar between the roots and the leaves (8). The majority of the tree stem is wood which consists of dead cells that provide a structure to support branches and leaves (Fig. 2). The heartwood, or very center of the tree, is used as a storage location for chemical byproducts that are not needed by the tree. These byproducts sometimes cause heartwood to be rot resistant such as with northern white cedar, increase its density, or even its beauty (e.g., black walnut) (8).

The sapwood (xylem) surrounding the heartwood is also comprised of dead cells but is critical for the transport of water and nutrients from the roots to the leaves. The yearly addition of new sapwood is the basis of diameter growth and replaces sapwood that becomes clogged and less efficient in transporting water and nutrients. The number of years that sapwood is used for transport before it becomes clogged varies with tree species (8). White and red oak use only the most current annual ring for transport because older sapwood cells become clogged or otherwise unusable within a year. Aspen uses several years of annual sapwood growth to transport water and nutrients. Other species such as birch, basswood and sugar maple, and the conifers as a group also can actively transport water and nutrients in older parts of the sapwood (2).

Wrapped around the outside of sapwood is a single thickness of cells known as the cambium. The cambium is responsible for producing new wood cells to the inside and bark cells to the outside (2). The rate of photosynthesis helps determine the rate at which this growing layer builds new cells. This, in turn, determines the rate of diameter growth.

The most active period of growth is in the spring and early summer when nutrients and moisture are plentiful (2). The cambium layer is weak in the spring and early summer and causes the easy separation of the bark

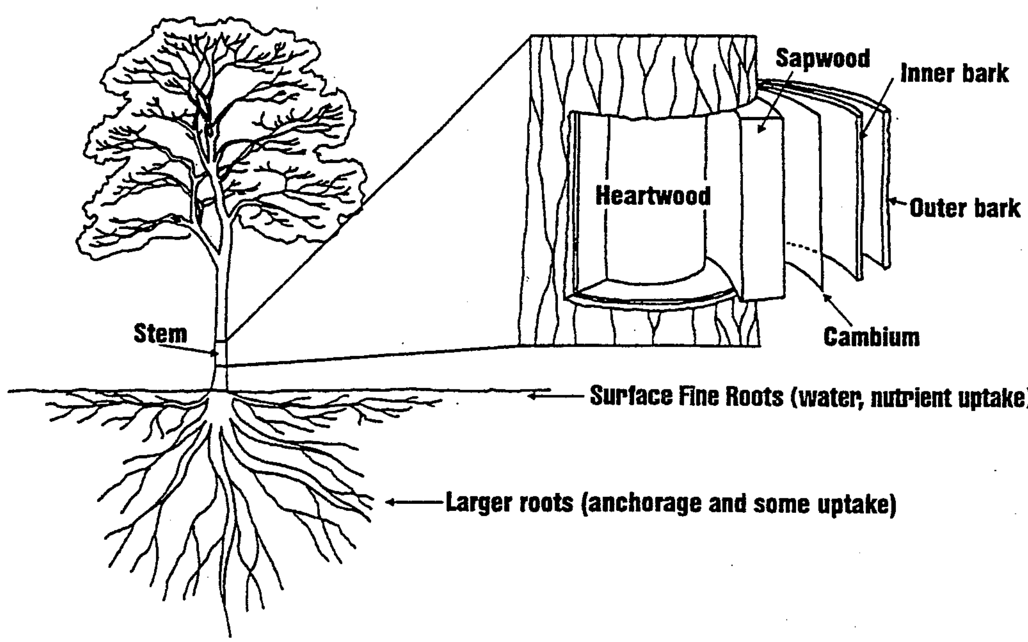

Figure 2: A tree is the sum of many parts. The crown has branches and leaves; the stem has heartwood, sapwood, cambium, inner bark and outer bark; and the roots extend in many directions to hold the tree upright and collect the water and nutrients necessary for photosynthesis and growth. (Stem segment used with permission, Champion International Corporation).

from the tree, hence the term bark slippage or slippery bark. Therefore, stem damage from skidding is potentially greater during the spring and early summer. Stem damage, in general, causes a reduction in tree growth, vigor and health. A damaged stem must use stored sugars (that otherwise would be used for growth) to build callus tissue to cover the wound. If the wound is large, staining and decay lowers the value of the stem and the tree wastes energy trying to cover the wound. Identifying and using bumper (rub and turn) trees along the inside corners of skid trails and then removing them when skidding is completed helps avoid damage to stems that will remain in the forest after the harvest.

The inner bark (phloem), which lies directly outside the cambium, is the part of the stem that is responsible for the movement of sugars and other compounds up and down the tree (2). As with the sapwood, there are thin annual rings within the inner bark. In contrast to the sapwood, as the tree expands, the inner bark is stretched and pushed outwards. The inner bark eventually becomes part of the outer bark. The true outer bark is produced by the cork cambium and it protects the delicate tissues inside of it from injury, insects and disease (2).

The crown of the tree is the combination of branches and leaves. This is an important part of the tree that needs protecting during harvest operations. Indiscriminately felling trees into crowns of trees that will remain can cause significant breakage of branches. This breakage provides ready entry points for decay-forming organisms and physically impairs photosynthesis by reducing the number of branches and leaves in the crown.

Summary

More leaves and roots mean more photosynthesis. A reduced branch and leaf number or root damage reduces a tree's ability to produce sugars for stem growth and elongation. Care must be taken in removing trees during harvest operations so that damage to the roots, stems and crowns of remaining trees is minimal.

Acknowledgment

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References and Sources of Additional Information

1. Koelling, M.R. and R.B. Heiligmann. 1993. Forest Resource Management Terminology. Michigan State University Extension. North Central Regional Extension Publication No. 478. 16p.
2. Kramer, P.J. and T.T. Kozlowski. 1979. Physiology of Woody Plants. Academic Press, Inc., New York. 811p.
3. Perry, D.A. 1994. Forest Ecosystems. The John Hopkins University Press. Baltimore. 649p.
4. Pritchett, W.L. and R.F. Fisher. 1987. Properties and Management of Forest Soils. 2nd edition. John Wiley and Sons. New York. 494p.
5. Smith, D.M., B.C. Larson, M.J. Kelty and P.M.S. Ashton. 1997. The Practice of Silviculture. 9th ed. John Wiley and Sons, New York. 537p.
6. Spurr, S.H. and B.V. Barnes. 1980. Forest Ecology. 3rd edition. John Wiley and Sons, New York. 687p.
7. Wenger, K. F. (editor). 1984. Forestry Handbook, 2nd Edition, Wiley Inter-Science Publication. John Wiley & Sons, Inc. New York. 1335p.
8. Zimmerman, M.H. and C.L. Brown. 1971. Trees: Structure and Function. Springer-Verlag, New York. 336p.

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