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

UNIT THREE

SOILS AND SITE PRODUCTIVITY

D. O. Lantagne, J. B. Hart, C. R. Blinn

MICHIGAN STATE UNIVERSITY EXTENSION

Extension Bulletin E-2637 March 1998

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 third bulletin describes the importance of soil and the process by which it provides trees with the essential components required for establishment and growth.

The primary differences between agricultural and forest soils are the presence of a litter layer on the forest soil surface containing partially decomposed material and the presence of permanent forest vegetation (7). These are two important distinctions not to be overlooked.

In an agricultural setting, the crop and the nutrients it contains are removed annually. This means that nutrients (usually through fertilization) must be added to maintain site productivity. In addition, crop rotation and the incorporation of organic matter (live or dead plants) are important tools used to maintain site and soil productivity within agricultural fields (9). Productivity can be measured as tons per acre, board feet per acre, or cords per acre in a forestry context or bushels per acre in an agricultural context.

In forests, permanent vegetative cover annually adds organic matter back to the soil and moves nutrients, through root absorption, from the soil to the tree. Many nutrients then are returned in the leaf litter that falls each year, as well as dead trees which fall to the ground. This recycling of nutrients and organic matter helps maintain soil productivity of forest sites (7). The removal of whole trees or logs during harvesting removes nutrients stored in the tree. When this is done on a rotation suited to the site, there are no long-term site productivity losses (Fig. 1) (7). The harvest of small high quality tree stems and bark before they reach peak

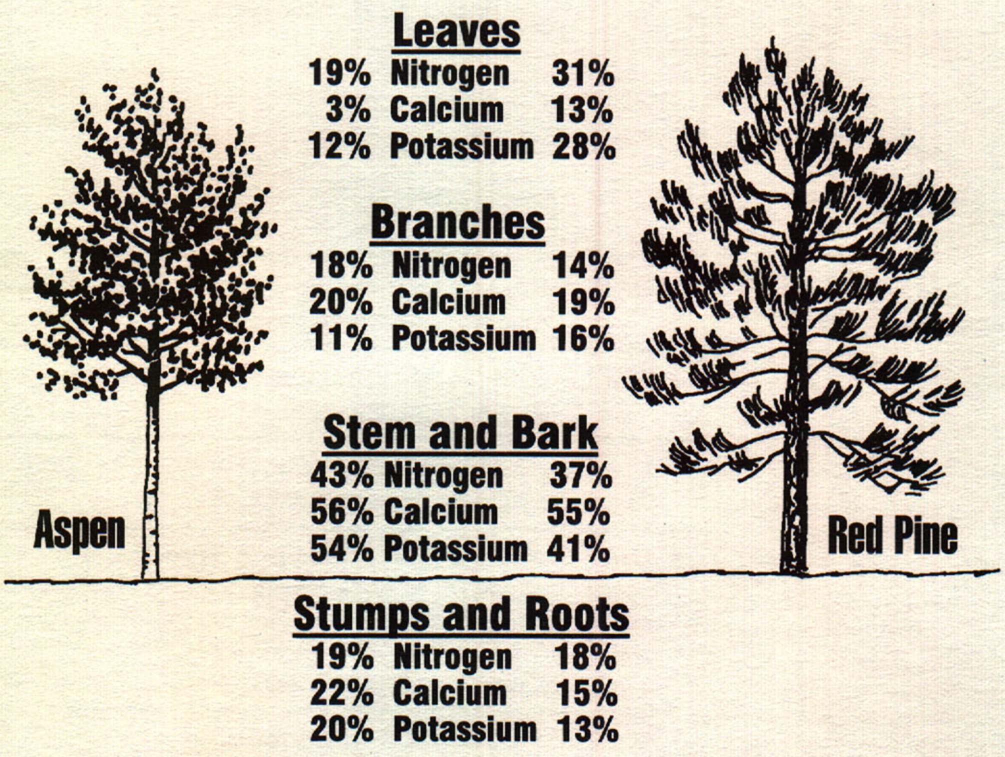

Figure 1: The distribution of total nutrient content on a per acre basis for aspen and red pine. The relative percentage of nitrogen, calcium and potassium within the species has been proportioned between the leaves, branches, stems, bark, stumps and roots (Alban et al. 1978). (Percentages on the right and left within the boxes correspond to the respective tree species in the drawing. Percentages may not equal 100 due to rounding.)

size and financial maturity would appear to cause a greater potential economic loss to the landowner than any potential economic loss due to short-term nutrient drain.

In addition to nutrients, all soils must include water and air, two critical components necessary for the growth of trees. Roots need air in the soil to respire and for efficient absorbtion of water and nutrients for plant growth (4). The two other major constituents of soil are mineral particles (sand, silt and clay) and organic matter (dead and decaying plant parts) (Fig. 2). Organic soils such as peat, which are often found in wet locations, are the result of slow decomposition of dead plant parts due to a shortage of air needed for rapid breakdown (3). Mineral soils, such as a loam, are comprised of mineral particles ranging in size from very fine (clay) to coarse (sand and gravel). Mineral soils are most productive when they have a 3 to 5 % organic matter content in the surface soil layer (7). This level of organic matter usually means the soil has a good physical structure for root growth, air infiltration, water infiltration and water holding capacity (9). Organic matter, which holds many times its own weight in water, is especially critical on sandy soils where water for plant growth can be in short supply (7). Organic soils can also support productive forests in the Lake States, as in the case of many northern white cedar stands.

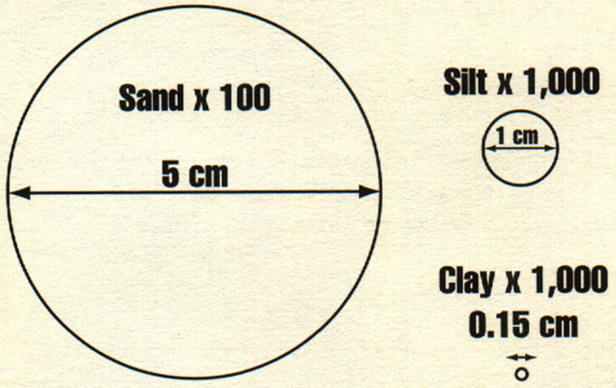

Figure 2: Soil particles come in different particle sizes. Clay is the smallest, sand is the largest, excluding stones and rocks, and silt size falls between that of sand and clay. Expanding an average size clay and silt particle 1,000 times and a sand particle only 100 times results in the above diameters. The most productive soils are usually found where there is a mixing of these soil particles. These soils are sometimes called loam soils. There are problems associated with tree growth on soils comprised predominantly of any one soil particle size.

The wide range of soil productivity found in forest stands is due to the relative proportions of the four basic ingredients of soil: mineral particles, organic matter, water and air (7). The combination of these soil ingredients in different proportions determines the level of air, nutrient and water holding capacity of each soil and the overall soil productivity. The result is a series of soil types from sands growing jack pine to clay loams growing high quality sugar maple.

The proportion of air, water, mineral and organic particles also affects the ability to operate on sites during inclement weather (trafficability). Clayey soils hold more water and are composed of smaller particles that are potentially more fertile (Fig. 2) (9). But they also compact more easily during logging in moist conditions and are more subject to rutting in wet conditions. Clayey, silty and loamy soils are more easily eroded and can be difficult to work on in many seasons of the year as compared to sandy soils.

Soil compaction from use of skidders, trucks and other heavy equipment reduces the space available between soil particles for both soil air and water. This can damage existing roots, and reduced available space can cause reduced root growth which, in turn, affects tree growth and site productivity. Contrary to common thought, several years of freezing and thawing during the winter may be required to lessen soil compaction (1). With many species, 80 percent or more of water and nutrient absorbing tree roots can be found

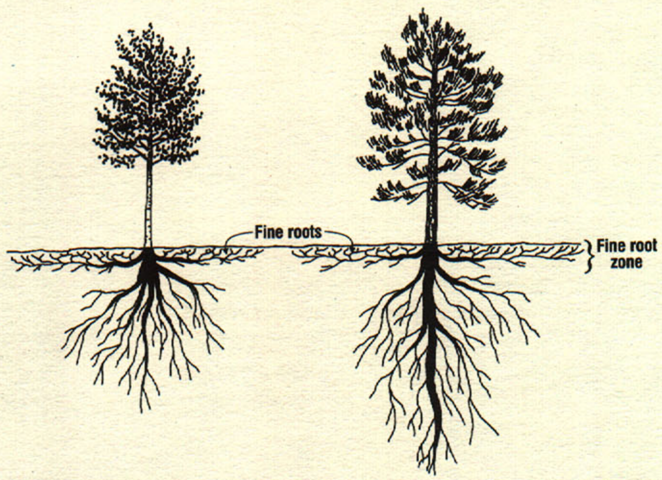

Figure 3: Although large tree roots can extend to great soil depths, a majority of the water and nutrient absorbing tree roots are found near the soil surface. Deep roots function as anchors (Spurr and Barnes 1980).

within 6 to 12 inches of the soil surface (8) (Fig. 3). Deeper roots are less important to nutrient uptake but are most important for support and sometimes water uptake. On sandy soils trees tend to have deeper rooting.

Skidder and other equipment traffic confined to established trails will minimize the extent of the area damaged in the forest. This is especially important on sites with finer textured soils, such as clay and loam, since these soil types are more susceptible to compaction, rutting and erosion.

Summary

Similar to traditional agricultural cropping systems where poor soil drainage can occur when operating on poorly drained soil or under wet soil conditions, harvest operations in forests can also have a significant impact on soil physical properties, roots and nutrient availability. This also can reduce the growth rate of remaining trees. Soil compaction, soil erosion, and root damage can seriously reduce the productivity of a site after harvesting operations are completed.

Acknowledgment

Funding was provided by the USDA Forest Service–Northeastern Area of State and Private Forestry.

References and Sources of Additional Information

1. Alban, D.H., G.E. Host, J.D. Elioff, and D. Shadis. 1994. Soil and vegetation response to soil compaction and forest floor removal after aspen harvesting. USDA Forest Service North Central Forest Experiment Station Research Paper NC-315. 8p.
2. Alban, D.H., D.A. Perala and B.E. Schlaegel. 1978. Biomass and nutrient distribution in aspen, pine, and spruce stands on the same soil type in Minnesota. Can. J. For. Res. 8:290-299.
3. Boul, S. W., F.D. Hole and R.J. McCracken. 1973. Soil Genesis and Classification. Iowa State University Press, Ames, Iowa. 360p.
4. Kramer, P.J. 1983. Water Relations of Plants. Academic Press. New York. 489p.
5. McEvoy, T. 1992. Using Fertilizers in the Culture of Trees. Paragon Books, Richmond, Vermont. 148p.
6. Perry, D.A. 1994. Forest Ecosystems. The John Hopkins University Press. Baltimore. 649p.
7. Pritchett, W.L. and R.F. Fisher. 1987. Properties and Management of Forest Soils. 2nd edition. John Wiley and Sons. New York. 494p.
8. Spurr, S.H. and B.V. Barnes. 1980. Forest Ecology. 3rd edition. John Wiley and Sons, New York. 687p.
9. Tisdale, S.L. and W. L. Nelson. 1975. Soil Fertility and Fertilizers. 3rd Edition. Macmillan Publishing Co., Inc. New York. 694p.
10. Wenger, K. F. (editor). 1984. Forestry Handbook, 2nd Edition, Wiley Inter-Science Publication. John Wiley & Sons, Inc. New York. 1335p.

SUSTAINABLE FORESTRY EDUCATION
LANDOWNER · LOGGER · FORESTER

MICHIGAN STATE UNIVERSITY EXTENSION

UNIVERSITY OF MINNESOTA Extension SERVICE

MICHIGAN STATE UNIVERSITY EXTENSION

MSU is an Affirmative-Action Equal-Opportunity Institution. Extension programs and materials are available to all without regard to race, color, national origin, sex, disability, age or religion. ■ Issued in furtherance of Extension work in agriculture and home economics, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Arlen Leholm, extension director, Michigan State University, E. Lansing, MI 48824. ■ This information is for educational purposes only. References to commercial products or trade names does not imply endorsement by MSU Extension or bias against those not mentioned. This bulletin becomes public property upon publication and may be printed verbatim with credit to MSU. Reprinting cannot be used to endorse or advertise a commercial product or company.

Produced by Outreach Communications and printed on recycled paper using vegetable-based inks.

3:98-2.5M-TCM-UP - Price $0.50 0-21684