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

UNIT FOUR

NUTRIENTS, CYCLING AND TREE GROWTH

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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 fourth bulletin describes the nutrient cycle and its importance in maintaining long-term site productivity, even with periodic timber harvests.

Nitrogen, phosphorus, potassium, magnesium and calcium are five elements that are essential for plant growth (4). The last four nutrients are released by dissolving mineral particles in the soil. This is a very slow process, and the nutrients in the soil and the vegetation today are the result of many years of weathering. While there are small amounts of these nutrients deposited on the soil surface each year from rainfall, soil weathering is the most important process for making available these four nutrients (3). In contrast, nitrogen does not originate from mineral weathering but enters the soil from the air when nitrogen gas is removed or "fixed" from the atmosphere by soil bacteria or lightning and used to make ammonia and nitrate (3).

Nitrogen is primarily associated with organic matter (live or dead plants) and is often the nutrient in shortest supply for plant growth in the ecosystem (2). In general, most of the nutrients found in soils are bound up in the dead plant materials (organic matter) or attached to soil particles. In the case of nitrogen, 95-98 percent of the total available in the forested ecosystem is associated with organic matter (4). Therefore the maintenance and decomposition of organic matter is critical to the flow of nitrogen in the forest ecosystem (3) (Fig. 1).

The decomposition of organic matter is dependent upon the work of soil organisms such as fungi, bacteria, worms, and insects. These organisms are responsible for the breakdown of organic debris back into nutrients, carbon, oxygen, carbon dioxide and other items. The nutrients released from rotting organic matter were captured previously by plants and incorporated into roots, stems, and leaves.

Plant parts are returned eventually in nature as organic debris to the forest floor where soil organisms do their job of releasing them back into the soil for absorption by other plants. This results in a process called nutrient cycling (6) (Fig. 1).The recycling of nutrients found within organic matter is very important to long-term site productivity. The forest floor and soil organic matter represent one of the largest single sources of the available nutrients needed for plant growth (2). Since nitrogen must first be absorbed or fixed by soil bacteria and converted into an organic form, the decomposition of organic matter is the only readily available source of nitrogen for most plant species; it is critical to plant growth on most sites (3).

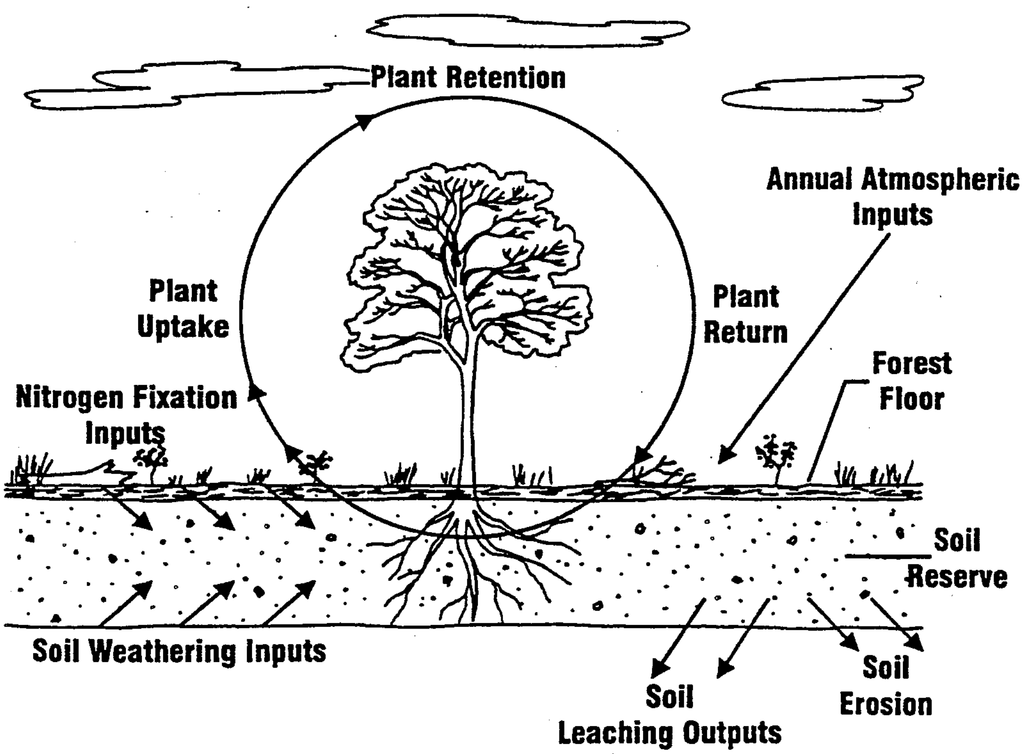

Figure 1: A graphical description of how nutrients move within a forest ecosystem and sources for additional nutrients to meet the needs of growing trees and to replace losses due to timber harvesting or soil leaching.

Within the forest, nutrients are located in one of three major sources: the organic matter (forest floor), the mineral soil horizons (dirt), and the plants or animals (4) (Fig. 2). Plants need a certain amount of nutrients from the soil and energy from sunlight to grow.

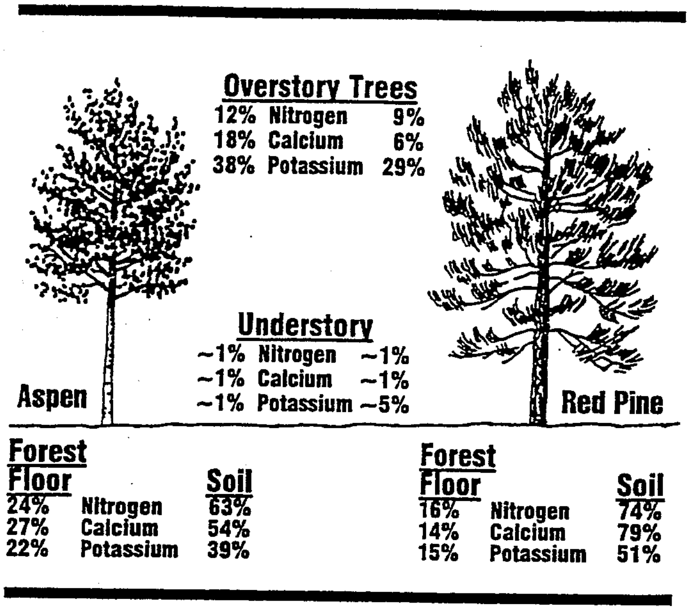

Figure 2: Distribution of the total amount of nitrogen, calcium and potassium found on a acre within overstory trees, understory plants, the forest floor, and the soil for both aspen and red pine (Alban et al. 1978). Percentages for each species may not total to 100 due to rounding. Percentages on the right and left are associated with the respective forest species shown in the figure.

The level of nutrient uptake varies with forest species. But in many forest types 70-80 percent of the nutrients absorbed in any one year are returned to the soil surface as leaf litter for future use (2). This continual re-use or cycling of nutrients in the forest ecosystem is an important aspect of the nutrient cycle. The accumulation of nutrients in the forest ecosystem over time is typically equal to the amounts that are deposited from the atmosphere, biologically fixed and soil weathered (3). That's why, over the life of the forest, nutrients accumulate and trees grow.

Timber harvesting affects nutrient reserves on harvested sites in several ways (6). First, leaching losses (water carrying nutrients deeper than the rooting zone) may occur when the forest floor is exposed to increased sunlight. The resulting increased soil temperature often encourages increased numbers of decomposing soil organisms which in turn increase the rate of organic matter decomposition (3). Because the vegetation remaining after harvest may not be able to absorb all the nutrients released through this accelerated decomposition, water moving through the soil can carry or leach away these unbound nutrients. In general, leaching does not result in large nutrient losses from a site, but there may be critical losses on some sites that are already low in soil nutrient availability (3). The quick regeneration of trees, forbs, wildflowers and grasses usually minimizes this overall loss to the system. Of course, in a thinning operation, trees remaining on the site are able to use the released nutrients for increased growth.

A second source of nutrient loss is associated with soil erosion. Soil erosion physically moves and deposits soil particles and their attached nutrients to locations that may not be available for regenerating vegetation, such as streams and ditches. The areas of the harvesting operation with landings, logging roads and heavily used skid trails have high levels of exposed mineral soil susceptible to erosion. Limit site disturbance as much as possible during and after harvest to minimize soil and nutrient loss. Using water bars on skid trails and roads, spreading slash to protect bare mineral soil and seeding exposed areas are all good management techniques.

A third source of loss is the direct nutrient removal when a tree is harvested. Nutrient removal associated with whole-tree harvesting is greater than that associated with shortwood or tree-length harvesting (3) (Fig. 3). Whole-tree harvesting removes branches, twigs and sometimes leaves, which is where nutrients tend to be concentrated in trees. Shortwood and tree-length harvesting only removes the stem and bark, which on a percentage basis contain very little of the overall quantity of a tree's nutrients. The good news is that the nutrients in shortwood and tree length removals are approximately equivalent to the quantity of nutrients that

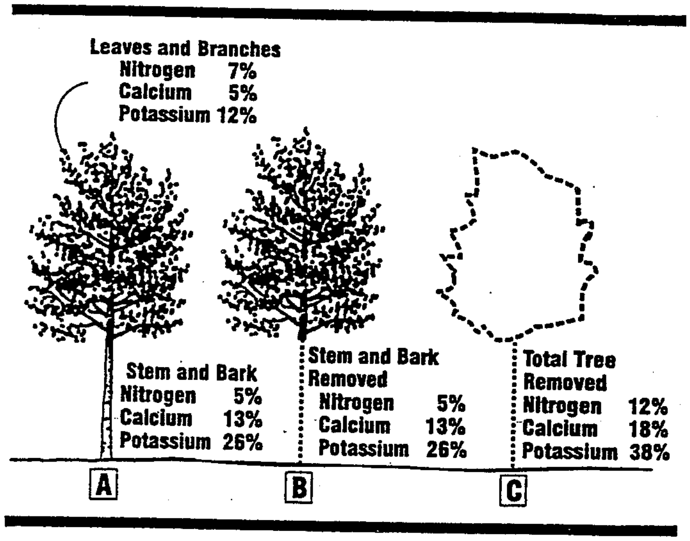

Figure 3: The first tree (A) is an example of an aspen and the percentage of nutrients on an acre that are contained within the leaves, branches, stem and bark (Alban et al. 1982). If the tree is removed in a bolewood only harvest (B), some proportion of the nutrients stay on the site. If the entire tree is removed (C) when leaves are present, the entire proportion of the nutrients that has accumulated in the tree is removed from the site. In either harvest situation, atmospheric input and soil weathering are believed able to replace the removed nutrients over normal harvesting rotations on most average sites (3, 7).

accumulate via atmospheric deposition and soil weathering over a fairly long rotation (3, 7).

Slash remaining after shortwood and tree-length harvesting also contains accumulated nutrients that are released to the next crop as the slash decomposes. However, if all the slash is piled at the landing, nutrients are not spread evenly across the site.

As long as the logging slash, the forest floor, and the mineral soil contain enough nutrients, you can expect to re-establish a new healthy growing forest. Soil weathering, atmospheric deposition and nitrogen fixation further add to the nutrient levels each year. These nutrients are accumulated in the biomass (the plants) of the new forest. Based on available data, forest soil productivity on most sites in the Lake States region should not be negatively affected by normal timber harvesting (7). Nutrient replacement from the atmosphere and weathering from soil minerals should be sufficient to replace the nutrients removed during harvests conducted under normal rotations (3).

If sites are low in nutrients (e.g., sands), have frequent whole-tree harvests, fire and soil erosion, then more nutrients might be removed and lost than can be replaced naturally by soil weathering, atmospheric deposition or that remain in the residual organic matter. On these nutrient deficient sites, to be conservative, harvests should occur over longer rotations, tree-length or shortwood harvesting should be used, and slash piled at the landing redistributed across the site during the harvesting operation. Selection harvesting may be an effective option to maintain nutrient levels on such sites with low nutrient reserves.

Summary

Harvest operations remove nutrients stored in trees, but the percentage of nutrients removed does not normally affect site productivity. Inputs from soil weathering, atmospheric deposition and other means are sufficient to offset losses from timber harvest on the majority of sites.

Where timber harvesting has the potential to deplete nutrient reserves within the soil, alternative strategies (e.g., longer rotations, slash distributed across the site) can mitigate those affects. For example, spreading slash over the site distributes nutrients as compared to a brush pile at the landing. In addition, good planning can help protect soils from erosion and help protect the watershed. Use good forest practices and site productivity will be maintained on almost any forest site.

Acknowledgment

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