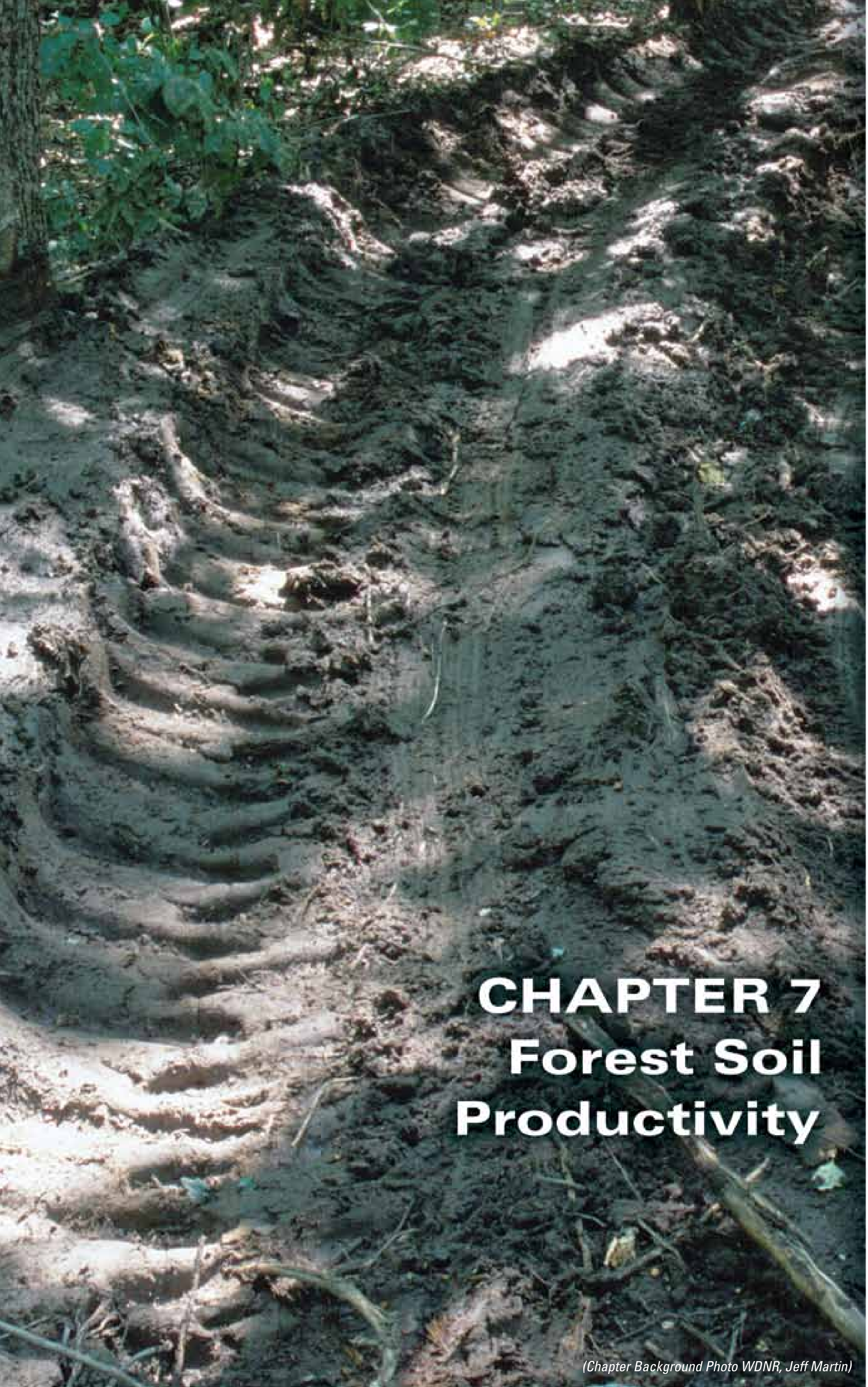

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CHAPTER 7
Forest Soil Productivity

(Chapter Background Photo WDNR, Jeff Martin)

CHAPTER 7
FOREST SOIL PRODUCTIVITY

THE VALUE OF FOREST SOIL PRODUCTIVITY

Sustainable Soil Productivity

Soil productivity is defined as the capacity of soil, in its normal environment, to support plant growth. It is reflected in the growth of forest vegetation or the amount of organic material produced by plants and animals. In forest management, soil productivity is often measured in volume of trees produced, but other methods of determining productivity exist (Fisher and Binkley 2000, p. 408).

Soil is one of the fundamental resources of the forest. Identifying and minimizing impacts to the soil is an essential part of sustainable forest management. Primary considerations in maintaining soil productivity include the following:

- Soil productivity is a major factor in determining the amount of timber harvesting that can be sustained over time. It also affects other forest attributes, such as wildlife habitat, biodiversity, and ecosystem services. Maintaining the productivity and sustainability of forest soils is key to meeting society's need for forest products and other amenities of the forest.
- Soil productivity is a strong influence on the species of trees that will grow on a site as well as their rate of growth (Fisher and Binkley 2000, pp. 412-413).
- Maintaining soil productivity keeps forest soils in a condition that favors regeneration, survival and long-term growth of desired forest vegetation.
- Maintaining forest soil productivity is less costly than correction or mitigation after soils have been damaged.

A certain amount of soil impact is inevitable when conducting some forest management activities. Many of the recommended practices are aimed at keeping this impact to a minimum level.


(WDNR, Jeff Martin)

Figure 7-1: A handful of soil can tell a forester much about the management prospects for a property.

SOIL CHARACTERISTICS AND POTENTIAL IMPACTS

Three Related Groups of Soil Characteristics

Soils have physical, chemical and biological components, all of which must be maintained to sustainably manage forests.

- The physical properties of soil include such factors as texture, structure, porosity, density, drainage, and hydrology (Fisher and Binkley 2000, p. 61).
- The chemical properties of soil include its nutrient status and rates of cycling, and pH (Fisher and Binkley 2000, pp. 87, 99).
- The biological properties of soil include the multitude of organisms that live in soil and have a role in plant growth. These include mycorrhizae, other fungi, bacteria, and many invertebrates (Fisher and Binkley 2000, pp. 118-119).

Impacts to soil physical properties have been shown to affect forest growth. It is known that harvesting removes site nutrients and alters aspects of the biological community, but there is less direct evidence for growth declines from these impacts.

Characteristic 1: Physical Characteristics of Soil and Potential Impacts

Soil physical properties are very important in determining tree species composition and rate of growth. These properties affect the amount and depth of rooting, the availability of water and the ease of water absorption by plants, the amount of oxygen and other gasses in the soil, and the degree to which water moves both laterally and vertically through the soil (Fisher and Binkley 2000, p. 61). Types of impacts that can occur during timber harvesting and forest management activities include compaction, puddling, rutting, and displacement. These disturbances often occur simultaneously and are almost exclusively caused by movement of heavy equipment during felling, forwarding, skidding, and site preparation operations. Vehicle tires bearing heavy loads compress and pack the soil down, resulting in soil compaction.

SOIL COMPACTION

Soil compaction is the increase in soil density resulting from loads applied to the soil surface. During the compaction process, soil volume is decreased primarily through the elimination of macropores (pores greater than 0.002 inches in diameter). Pore volume and pore size are key properties that govern air and water movement in the soil. Because of their relatively large diameter, macropores are particularly important in regulating the rates of water and gas movement (Fisher and Binkley 2000, p. 69).

The first few trips with heavy equipment over the soil surface produce the greatest increase in soil density (i.e., the most compaction; see Figure 7-2). Machine vibration may also contribute to compaction.

Soil compaction can decrease the rate of tree growth (Pritchett 1979, p. 444). Soil aeration is diminished, making oxygen less available for respiration in tree roots. Concentrations of carbon dioxide and other toxic gasses can build up, injuring roots. Soil micro-organisms that play a role in making nutrients available to plants are also negatively affected by the lack of oxygen and high levels of injurious gasses. Compaction further affects root growth by increasing soil resistance to root penetration. It decreases pore space, which reduces soil infiltration capacity (the rate of water movement into the soil), so that less moisture is available for plant growth. Also, when infiltration rates are reduced, more rainfall flows overland, which can increase erosion and sedimentation (Fisher and Binkley 2000, p. 69).

Recovery of compacted soil is variable depending on the severity of the compaction and local conditions. Compaction is a long-term rather than short-term effect. Severely compacted soils may require up to 40 years or more to recover naturally, according to Hatchell and Ralston, 1971. Froehlich and McNabb, 1984 state that "... the effects of soil compaction should be assumed to persist for several decades on forest sites."

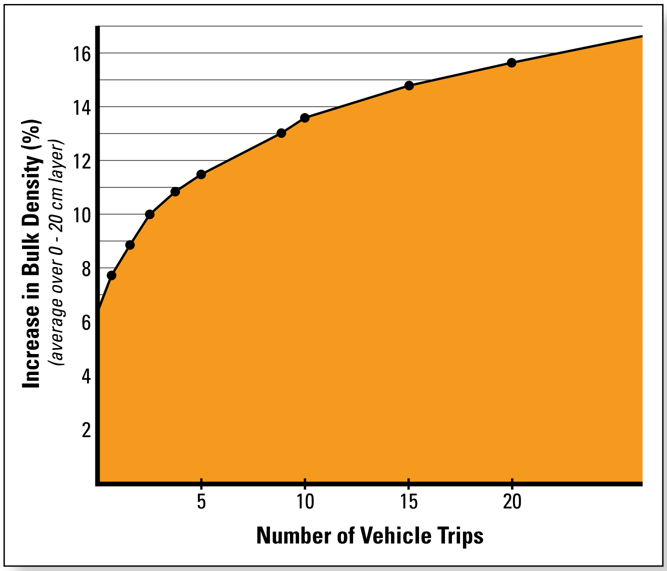

Figure 7-2: Effect of vehicle trips on soil density. *(Adapted from Froehlich et al., 1980)*

Figure 7-3: Severe soil compaction in this heavily grazed woodlot caused accelerated water runoff, which has eroded a deep gully.

Even in cold climates, where the action of freezing and thawing presumably loosens soils quickly, the density of compacted soils decreases slowly (Voorhees, 1983 and Corns, 1988). In an ongoing study in Minnesota and the Lake States (Stone and Elioff, 1998), no reduction in soil density has been measured after five years of intentional compaction.

Cattle can also cause soil compaction when allowed to trample the soil in forests and woodlots. Damage can be particularly severe when grazing pressure is heavy, soils are wet, and livestock use continues over a long time period. The physical damage to soils begins with the mixing and trampling of the cushioning forest floor layer, which quickly disappears under heavy livestock use. The bare soil is then compacted by repeated trampling – infiltration slows, runoff increases, and soil erosion occurs. As forest health declines, litter inputs are reduced and soil organic matter decreases, impacting site fertility. Tree roots may be directly damaged by hoof impacts that create wounds where insects and diseases can enter trees. Seeds, seedlings, and saplings of many tree species are browsed, reducing or eliminating forest regeneration and recruitment. Cattle also affect vegetation. In extreme cases, the herbaceous layer may disappear leading to additional loss of infiltration capacity and reductions in soil moisture. Aggressive non-native and sometimes invasive plants, many of which are spread by cattle, easily invade disturbed areas like these. Spiny or thorny plants that cattle do not eat are allowed to grow and may become overabundant, creating an impenetrable bramble. Livestock should be excluded from woodlands that support any quality trees or other desirable vegetation.

PUDDLING

Puddling is the loss of soil structure that results from squeezing and churning wet soils with the tires or tracks of heavy equipment. Puddling often occurs in ruts with standing water. Soil particles become dispersed in water, and after they have dried and settled, the smaller particles form a crust on the surface. Puddled soils affect forest regeneration and growth in ways similar to compacted soils (Fisher & Binkley, p. 69).

RUTTING

Rutting is the creation of depressions made by the tires of vehicles such as skidders, log trucks and pickup trucks, usually under wet conditions. Rutting occurs when soil strength is not sufficient to support the applied load from vehicle traffic.

- Rutting directly affects the rooting environment. It physically wounds or severs roots, compacts and displaces soil, and reduces aeration and infiltration, therefore, degrading the rooting environment.
- Rutting disrupts natural surface water hydrology by damming surface water flows, creating increased soil saturation up-gradient from ruts. Alternatively, ruts that run parallel to a slope gradient can divert water flow away from a site, drying or draining it, and sometimes contributing to erosion and sedimentation.
- Soil rutting typically occurs along with other physical soil impacts, including compaction and puddling.

DISPLACEMENT

The surface layers of most forest soils are very important to site productivity. These layers are rich in organic matter, contain the bulk of the soil's nutrient and moisture-holding capacity, and support the microbial population. Surface horizons cushion soil from traffic and buffer extremes in temperature. Organic matter contributes to soil aeration, and provides sites for seedling germination and rooting. Conserving organic matter is an important factor in maintaining site productivity. Displacement of surface soils, whether moved within a stand or removed from the site, can be detrimental.

Loose, sandy soils are sometimes impacted by heavy equipment that removes or wears away the surface vegetation during skidding and hauling – leaving the soil unprotected. On slopes or roadcuts, these sandy soils can slump downhill due to gravity, or can be eroded by wind and water. The continual displacement of the surface soil prevents revegetation on these areas, and removes them from productivity.

Figure 7-4: In this case, soil compaction and erosion is the result of heavy foot traffic on shallow soil along a popular trail. Injuries to roots and reduced aeration can kill trees. Similar damage can also be caused by livestock grazing, vehicle traffic, and other concentrated land uses.

SOIL EROSION

Soil erosion is not usually a major impact associated with forest management in most parts of Wisconsin, except when associated with roads and skid trails (see Chapter 12: Forest Roads). Erosion seldom occurs on areas with established vegetative cover, or on flat areas. Clearcut harvesting that temporarily removes all forest cover on steeper slopes can occasionally result in accelerated erosion. Extra care should be taken on silt, silt loam, loam, very fine sandy loam, sandy clay loam, silty clay loam and clay loam soils, as these soils tend to erode more easily when disturbed or exposed, especially on long slopes or slopes greater than 10 percent. Sometimes, large, dense infestations of certain non-native invasive plant species (e.g., honeysuckles) may contribute to increased erosion, as these species do not hold soil in place as well as native plants.

WATER TABLES

Forests on sites that have a water table near the surface are sometimes subject to a rise in water tables after a harvest. The rise in water tables, also known as "swamping out", occurs due to the loss of transpiration by trees. The increase in soil moisture can be sufficient to inhibit regeneration (Pritchett 1979, p. 459).

PROTECTING SOIL PHYSICAL PROPERTIES

- **Compaction and Rutting:** Soils most susceptible to compaction and rutting include fine-textured soils (silty clay, sandy clay and clay) and medium-textured soils (fine sandy loam, very fine sandy loam, loam, silt loam, silt, silty clay loam, clay loam, and sandy clay loam). Poorly and very poorly drained soils of any texture are susceptible to compaction and rutting during most years when not adequately frozen.

  Soils that are shallow to bedrock are also more susceptible to compaction, because soils can be compressed between vehicle tires and the rock surface.

  The susceptibility of soil to compaction and rutting is primarily dependent on soil texture and moisture content. Soils are most susceptible to compaction, puddling and rutting when they are saturated. Such conditions occur on upland sites during spring and early summer months, immediately following heavy rains, and in the fall after transpiration has ceased but before freeze-up. Limiting equipment traffic to drier seasons of the year is one way to reduce compaction and other types of physical damage to the soil (Fisher and Binkley 2000, p. 69).

  Soils that are solidly frozen are relatively resistant to compaction, so winter operations are an option for wetter sites. However, in recent years it has become increasingly difficult to freeze wetland soils for a sufficient duration to accomplish harvesting, particularly in southern Wisconsin. Organic soils, because of their wetness and low inherent bulk density, are particularly susceptible to compaction and rutting. Vehicle travel on unfrozen wetland soils can cause severe damage. More than 90 percent of the horizontal water flow in organic soil wetlands occurs at a depth of less than 12 inches below the surface (Boelter and Verry, 1977). Rutting in organic soils in wetlands can alter subsurface flow, resulting in either partial drainage of the wetland or additional water storage within the wetland, depending on where the ruts occur and their depth. These soil disturbances can also give a competitive advantage to reed canary grass, which may take over a forested wetland and prevent tree regeneration.

  The timing of forest management activities, type and placement of infrastructure, selection of equipment, and operating techniques are all critical factors in avoiding effects on the soil resource. It is important to avoid operating heavy equipment on a site when adverse soil impacts are likely, and to limit direct trafficking of a site to the smallest area possible.

  The preferred operating season for any one site may vary depending on local climatic conditions, equipment being used, and operating techniques. The use of low ground pressure (LGP) equipment and operating techniques such as the use of slash mats can extend operating seasons on low-strength soils. Infrastructure development, including roads, landings and skid trails, almost always results in direct soil compaction and reductions in forest growth. It is critical to minimize the area occupied by infrastructure to reduce the impact to soil productivity. For more information on how to obtain soil interpretations for equipment operation, see the Resource Directory.

- **Soil Displacement:** Mechanical site preparation techniques often involve soil displacement. Severe treatments that remove or displace the surface organic and mineral soil layer may result in nutrient removal and other site degradation (i.e., soil erosion or compaction).

  Site preparation techniques that move surface soil away from seedlings (e.g., dozing soil into windrows) should be avoided, as these practices remove much of the nutrient and moisture supply that a seedling needs. The loss of surface soil is of greater concern in some soil types. Coarse, dry soils and wet, fine soils, or soils shallow to bedrock, are most likely to be severely impacted (see Chapter 15: Reforestation and Afforestation, for more on selecting methods).

Retaining slash on site provides shelter and organic matter for seedlings. Although it may be difficult to plant a site with slash present, windrowing or piling of slash should be avoided, and scattering of slash should be encouraged.

Prescribed fire is sometimes used to reduce slash before planting, control competition or expose mineral soil for seeding. Fire is a useful tool but does change forest floor conditions by removing organic material that provides shelter and moister conditions for seedlings. Cooler fires that burn with an uneven intensity can leave patches of slash and litter providing a variety of conditions available to seedlings.

- **Erosion:** A severe erosion problem can occur on roads and skid trails that lack vegetative cover, resulting in downcutting of the roadbed and sediment delivery to streams. Accelerated erosion "may be most serious in shallow soils over bedrock" (Alexander 1988) Techniques for limiting soil erosion and sedimentation from roads are discussed in Chapter 12: Forest Roads.
- **Swamping:** Rises in the water table can be avoided by considering subsurface soil conditions and their effect on drainage, and avoiding excessive harvesting on these sites. Swamping typically occurs on "moist, level to gently sloping sites where lateral drainage is restricted and impervious layers prevent downward movement of water" (Pritchett 1979, p. 459).


(WDNR, Eunice Padley)

Figure 7-6: Compaction and rutting can cause ponding and slow water infiltration. Ponds may benefit amphibians, but they reduce forest productivity and can result in erosion and sedimentation.


(WDNR, Paul Pingrey)

Figure 7-5: Excessive ruts caused by logging equipment should be dealt with promptly – before rain or melt water turns them into major gullies.

Characteristic 2: Chemical Characteristics of Soil and Potential Impacts

Soil chemical properties include nutrient status of a soil and soil pH. Soil chemical characteristics are influenced by many factors, including soil origin, soil texture and drainage, degree of soil weathering and development, and organic matter content. Forest management affects the nutrient status of a soil/site through 1) removal of nutrients in forest products, and 2) disturbance of surface soils through harvesting and site preparation activities.

NUTRIENT CYCLING

Nutrient cycling is the process by which nutrient elements move into, out of and within an ecosystem. Forested ecosystems receive natural inputs of nutrients through atmospheric deposition and mineral weathering (see Figure 7-7) (Fisher and Binkley 2000, pp. 189, 202).

Throughout the life of a stand, these inputs can be very significant. Outputs of nutrients occur through timber harvesting or other practices that remove soil or organic material from the site, and through leaching and surface runoff.

NUTRIENT STATUS AND REMOVALS

Soils accumulate nutrients through mineral weathering and atmospheric deposition (Kolka et al. 1996. Nutrients are lost from a site through leaching, volatilization (in the case of nitrogen), and removals in harvested wood. If losses are greater than inputs over the course of a rotation, nutrient depletion can occur (Johnson et al. 1988). The likelihood of nutrient depletion is greater with shorter rotations, nutrient-demanding species, whole tree harvesting, and on sites with low inherent nutrient reserves (Fisher and Binkley 2000, pp. 237-239).

If nutrient losses are relatively small and the site is "rich," or has a large amount of nutrient capital, then harvest removals may not cause nutrient limitations for hundreds of years. However, if the site is sandy or shallow and has little nutrient capital, losses may result in nutrient depletion within a few rotations. The nutrient capital of sites in Wisconsin varies widely, depending on the origin of soil parent materials and the depth of soil. For example, a deep loamy soil formed in loess over glacial till may contain 50 times the amount of calcium in the rooting zone than a sandy soil formed in outwash deposits (Grigal and Bates 1992). Soils formed in sterile, quartzitic outwash sands have little potential for mineral weathering, as minerals are lacking in the parent material.

Soils shallow to bedrock have less nutrient-holding capacity because the volume of soil available to roots is smaller. This "affects nutrient and moisture supplies, root development, and anchorage against windthrow" (Fisher and Binkley 2000, p. 272). Gale and Grigal (1987) showed that even for deeply rooted tree species, 95 percent of fine roots occurred within the upper 40 inches of soil, indicating that this soil zone supplies nearly all of the available nutrients. Soils shallower than 40 inches are potentially more susceptible to nutrient depletion (Grigal and Bates 1992). Forest growth is correlated with depth to bedrock or another root-restricting layer (e.g., fragipan), with the greatest decline in growth evident on soils less than 10 inches deep (Fisher and Binkley 2000, p. 272).

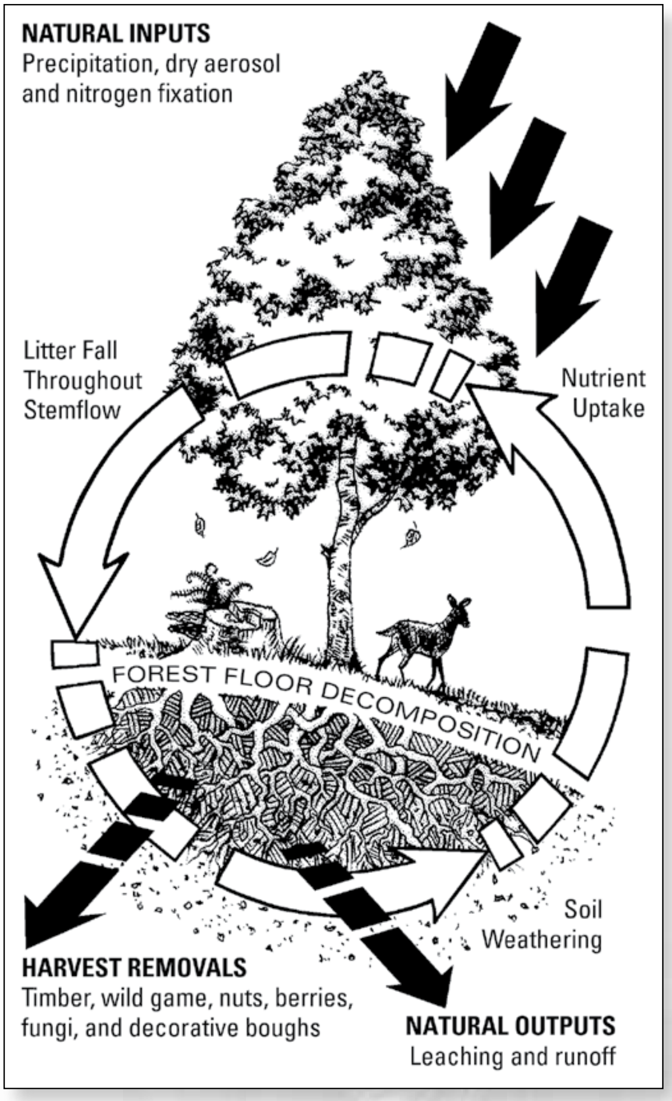

Figure 7-7: Nutrient Cycling (Adapted from Figure S-2, pg. 17, Forest Soil Productivity, Voluntary Site-level Forest Management Guidelines: Sustaining Minnesota Forest Resources)

Wetland soils also have a unique nutrient status. These soils are saturated to a zone near the surface, and mineral weathering is slowed by anaerobic conditions beneath the water table. Many of these soils receive nutrient inputs only from runoff, and are particularly susceptible to harvesting losses of potassium (K) and phosphorous (P). Grigal (2004) has estimated that for these kinds of sites in Minnesota, "about 30 percent of the system K and 20% of the P would be lost in each 50 year rotation…This is a consequence of the low rates of natural K and P replacement in peatlands, and implies a high potential for deficiencies to occur with intensive harvest" (Grigal 2004).

There is uncertainty in predicting the exact amount of potential nutrient losses due to harvesting, and more research is needed in this area. It is known that some tree species accumulate more nutrients than others, and harvesting nutrient-demanding species removes more nutrients from the site. Nutrient-demanding tree species include the aspens, oaks, and northern hardwood species (Perala and Alban 1982, Johnson et al. 1988, Rutkowski and Stottlemyer 1993). A whole-tree harvest or a harvest for woody biofuels removes more nutrients than a bole-only harvest. When nutrient-demanding tree species are whole-tree harvested, or removed in biofuel harvests on sites with limited nutrient capital, concerns for potential nutrient depletion are greatest.

Nutrients are stored in different amounts in various parts of a tree. On average, about half of the mineral nutrients are contained in tree tops (material less than 4” diameter); however, the amount varies by species and season. Some species, (e.g. aspens) store a large amount of calcium and magnesium in the bark, while conifers hold proportionately greater amounts of nutrients in their foliage.

Seasonal translocations of nutrients among tree components are of interest in deciding whether to harvest in the summer, when the foliage of deciduous trees would be removed during whole-tree harvests, versus harvesting in winter. Textbooks describe the translocation of 1/4 to 2/3 of nitrogen out of the leaves of deciduous trees in autumn (Kozlowski and Pallardy 1997); however, there is considerable variation among tree species, and by individual nutrient considered. Much of the autumn translocation moves nutrients from leaves to twigs and small branches, which are still removed in a winter whole-tree harvest, so the overall nutrient benefits gained by a winter harvest appear to be relatively small (Grigal and Bates 1992, Pastor 1989, Pastor and Bockheim 1984, Johnson et al. 1982). Seasonal harvest restrictions may be important for other reasons, such as avoiding nesting disturbances to wildlife species.

Factors that affect the amount of nutrient removal associated with timber harvest include 1) type of harvest and amount of material removed, 2) tree species and components (branches, foliage, bole, bark) being harvested, and 3) season of harvest. For example, a whole-tree harvest during the growing season removes virtually all nutrients stored in the above-ground part of the trees. In the case of a bole harvest with limbing at the stump, nutrients in the crown and other non-merchantable portions are retained on site. If trees are skidded to a landing before limbing, the nutrients in the crown are removed from the immediate vicinity, but could be moved back into the stand.

At present there are no instances where forest growth in Wisconsin has been positively linked to nutrient depletion; however, there are relatively few studies of this topic, and nutrient balance calculations project that this depletion could occur in the future. Studies in Michigan on sandy outwash soils found nutrient depletion in conjunction with whole-tree aspen harvest (Stone, 2001). This is a concern for Wisconsin sites with low nutrient capital.

Prescribed fire is a forest management tool used in site preparation and in controlling competing vegetation. For the portion of organic material that is completely consumed in a prescribed burn, nitrogen and some phosphorus are volatilized and lost to the atmosphere. Meanwhile, inorganic forms of phosphorus, along with calcium, magnesium, and potassium, are left in the ash in a “mineralized” form that is readily available to plants (Grigal and Bates 1992). Usually combustion is far from complete, depending on season and moisture conditions at the time of the burn, so a considerable amount of organic material typically remains on site. Losses of nitrogen are not considered significant under most prescribed burn conditions. Mineralized nutrients are susceptible to leaching, but usually are retained on site through soil immobilization and uptake by vegetation (Grigal and Bates 1992). Factors to consider are the timing of prescribed burns, site moisture conditions, and the temperature of the fire. Volatilization of nitrogen and organic phosphorus will be less with cooler fires, and leaching will be minimized on sites where vegetation is actively growing after the fire. Fires that burn unevenly can retain patches of organic material on site for decomposition and longer-term nutrient release.

Figure 7-8: Retaining slash on skid trails is an effective way of reducing soil compaction and rutting from use of heavy logging machines.

NUTRIENT-RETENTION STRATEGIES

- Retain or redistribute slash on the site
- Avoid whole-tree harvesting on nutrient poor sites.
- Avoid whole-tree harvesting of nutrient demanding tree species.
- Add nutrients to the site (in Wisconsin, forest fertilization is not a generally accepted practice, and additional analysis would be needed to determine whether water quality impacts or other unintended consequences would be a concern).
- Avoid shortened rotations

Many modern harvesting systems require full-tree skidding for efficiency of the operation. In these situations, slash can be redistributed out to the site from the landing. Caution should be exercised during non-frozen seasons to avoid trafficking additional areas while redistributing slash. The negative effects of soil compaction due to increased trafficking could outweigh the positive benefits of redistributing slash. It may be advantageous to leave clumps of slash (drags left along skid trails) or leave slash in the skid trails.

Characteristic 3: Biological Characteristics of Soil and Potential Impacts

Biological characteristics of soil include the populations of plants and animals, including microflora (fungi, bacteria, algae) and microfauna (worms, arthropods, protozoa). Forest soils contain a multitude of microorganisms that perform many complex tasks relating to slash and litter decomposition, nutrient availability and recycling, and tree metabolism and growth. Generally, the number of organisms is greatest in the forest floor and the area directly associated with plant roots (Pritchett, 1979).

The population of soil organisms (both density and composition) and how well that population thrives is dependent on many soil factors including moisture, aeration, temperature, organic matter, acidity, and nutrient supply (Pritchett, 1979).

Mycorrhizae are soil fungi that grow into tree root hairs, forming a symbiotic relationship that is important in nutrient uptake for most tree species, particularly on nutrient-poor sites. Mycorrhizal tree species include pines, spruces, firs, maples, ashes, birches, beeches, oaks, basswoods, black walnut, black cherry, and willows. Afforestation has proven difficult in areas where mycorrhizae are not present in the soil, and trees planted in such sites are sometimes inoculated with a mycorrhizal fungus to improve establishment Loss of the forest floor layer, or deforestation that dries and warms a site, can negatively impact populations of mycorrhizal fungi (Fisher and Binkley 2000, pp. 111, 174).

Infiltration of moisture into the soil is aided by dense ground vegetation and thick forest floor, or duff layers, that act to intercept and hold rainfall. Activities that remove or thin the herbaceous plant cover and duff layer will contribute to greater runoff and potential erosion. The use of vehicles in forested sites can damage ground vegetation and remove or displace the forest floor layer. Trampling and grazing by cattle can also have these effects, particularly when combined with soil compaction that also reduces infiltration capacity. Some non-native invasive shrubs contribute to reduced infiltration, by capturing virtually all available sunlight so that no herbaceous plants grow beneath them, leaving the soil bare and unprotected.

Some non-native invasive plants directly change the chemistry and interrelationships of mycorrhizal fungi. Common buckthorn leaves are very high in nitrogen and decompose very quickly. This alters the soil carbon: nitrogen ratio that favors invasive species. It also reduces the leaf litter layer and organic matter in the soil, thereby reducing water infiltration rates and water holding capacity. This combination makes seedling germination and survival difficult for any native trees and understory plants. Garlic mustard interferes with tree regeneration by releasing chemicals that harm a soil fungus many trees depend on for growth and survival. Some bush honeysuckle species release chemicals into the soil which inhibit the growth and reproduction of other plants and act as a deterrent to insect herbivory. (See Forestry BMPs for Invasive Species [IS-BMPs] on page 7-13 and in Chapter 8: Invasive Plants, Insects and Diseases.)

"Pit and mound topography" is a term that refers to the soil surface in a forest where occasional large trees have fallen or been blown down. The tree's root system pulls up a mound of soil, leaving a pit where the tree formerly stood. These pits are important sites for water infiltration into soils, especially on slopes, and also create puddles and ephemeral pools that benefit amphibians and invertebrate organisms. Harvesting reduces the likelihood of treefalls that create pits and mounds, and equipment travel tends to smooth the surface of forested sites (Schaetzel 1989). Maintaining a component of reserve trees that are allowed to fall down can help retain pit and mound topography.

Physical and chemical soil characteristics can be influenced by forest management as previously discussed. Impacts to these soil properties may directly impact soil biology, thereby impacting the functions of the organisms – many of which are beneficial to plant growth. Implementation of practices that protect the physical and chemical properties of the soil also protects the habitat of the soil organisms and sustains their populations.


(WDNR Archive)

Figure 7-9: Buckthorn, a non-native invasive species, has invaded this woodland in southern Wisconsin, changing the soil chemistry and reducing the water infiltration and holding capacity. These changes make tree seedling germination and survival difficult.

APPLYING GUIDELINES TO VARYING SITE CONDITIONS

Forests in Wisconsin grow on a variety of soils and site conditions. Some of these include 1) loamy and clayey soils formed in rolling glacial till, often overlain with a silt loam "loess cap" deposited by wind after glaciers melted, 2) silty or loamy soils formed in alluvial plains along rivers, 3) droughty sands formed in outwash plains or sandy lake sediments, 4) shallow soils overlying bedrock of various types, and 5) organic soils formed in wetlands.

Topography also varies greatly throughout Wisconsin. Much of the state displays glacial features like steep, hilly end moraines, gently rolling ground moraines, and nearly level outwash and lake plains. The unglaciated area of southwest Wisconsin has steep eroded hillsides and level valley bottoms. The Lake Superior clay plain has fine-textured clay soils that are highly-erodible, and if not managed properly can contribute a significant amount of sediment to streams.

Past management has also had a large effect on site conditions. The Cutover era of the late 1800s and early 1900s changed tree species composition, which changes the nutrient status of soils over time. The extensive and extremely hot slash fires associated with the Cutover consumed an atypical amount of forest floor and woody debris, which would also have affected soil properties.

Because site conditions vary, it is important for individuals making forest management decisions to evaluate the soil and topography of each site. Site-specific information helps the manager develop individualized prescriptions to ensure productive capacity is not reduced as a result of forest management activities.


(WDNR, Jeff Martin)

Figure 7-10: Skidder traffic, and hence soil compaction, can be reduced when the operator pulls cable to the logs instead of driving the machine to each one.

Figure 7-11: Retaining slash may be a bit unsightly, but it provides some shelter for new seedlings and adds organic matter and nutrients to the soil. When crushed by heavy equipment, it decomposes rapidly.

BMPs: Invasive Species

Soil disturbance can encourage an invasion of non-native plants which can have an impact on soil productivity. Consider the following Forestry BMPs for Invasive Species (IS-BMPs) to avoid or minimize impact to forest soils. (See Chapter 8: Invasive Plants, Insects and Diseases for more on invasive plants and IS-BMPs.)

- 3.4 Plan management activities to limit the potential for the introduction and spread of invasive species.
- 4.3 Consider the likely response of invasive species or target species when prescribing activities that result in soil disturbance or increased sunlight.