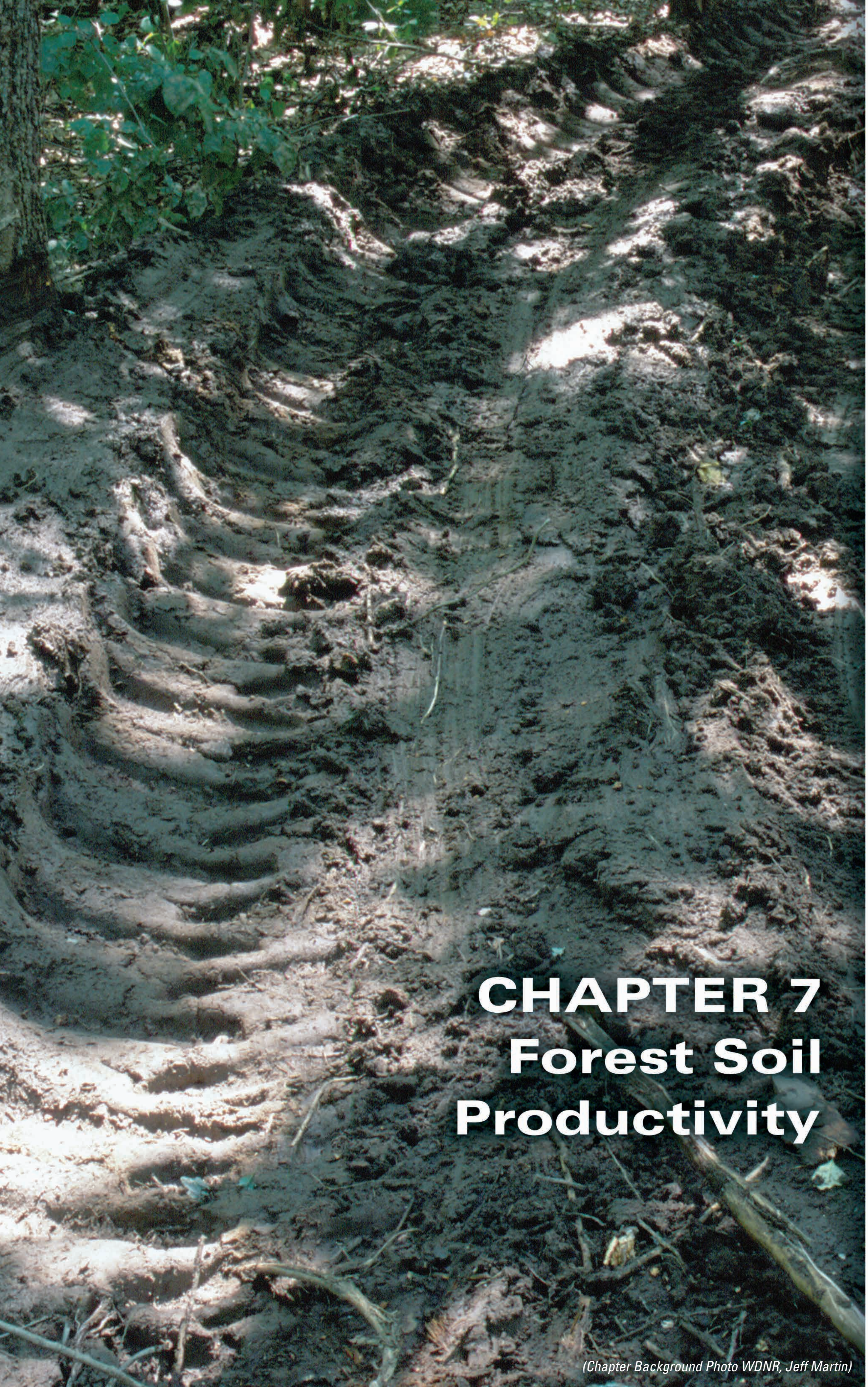
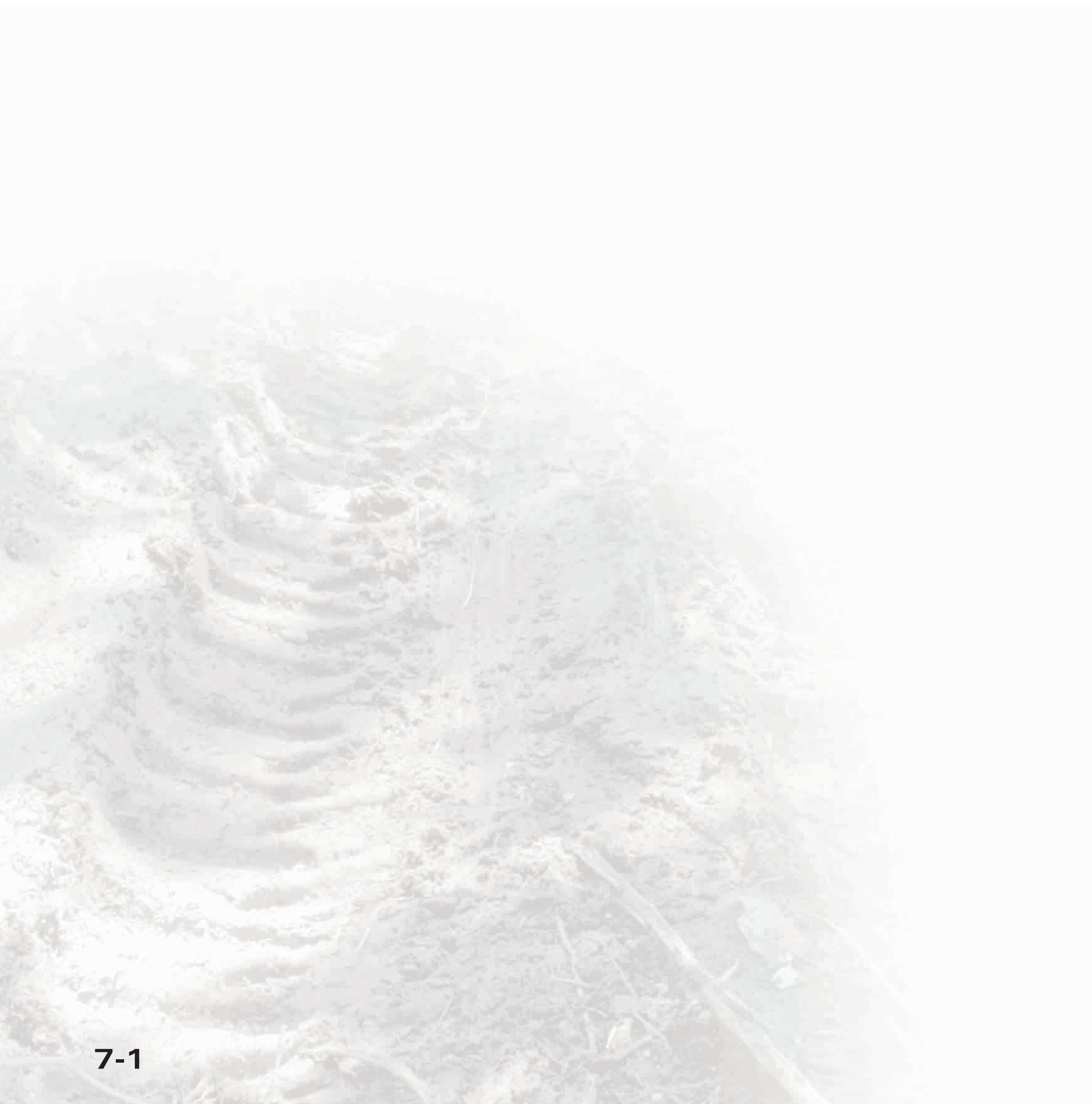


CHAPTER 7
Forest Soil Productivity

(Chapter Background Photo WDNR, Jeff Martin)

CHAPTER 7
FORESTSOIL PRODUCTIVITY



THE VALUE OF FOREST SOIL PRODUCTIVITY

Sustainable Soil Productivity

Soil productivity is defined as the ability of the soil, in its normal environment, to support plant growth. In forest management, soil productivity is often measured in species composition and volume of timber produced.

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

- Typically, the more productive a soil, the more timber harvesting that can be supported over time. It also affects other forest attributes, such as wildlife habitat, biodiversity and ecosystem services. Maintaining the productivity of forest soils is key to meeting society's need for forest products and other amenities of the forest, while ensuring future harvesting can be possible.
- Soil productivity is a strong influence on the species of trees that will grow on a site as well as their rate of growth.
- Maintaining soil productivity keeps forest soils in a condition that favors regeneration, increases survival, and increases long-term growth of the forest.
- Maintaining forest soil productivity is less costly than repair after soils have been damaged.

A certain amount of soil impact is inevitable when conducting some forest management activities. In some cases, soil impacts actually promote tree regeneration. This chapter will describe which practices help promote healthy forests and which practices are harmful to forests.

(WDNR, Jeff Martin)

Figure 7-1: Soil type can tell a forester about the potential species the soil is capable of producing, along with the potential growth rates.

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.
- The chemical properties of soil include its nutrient availability and rates of nutrient cycling, and pH level.
- 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.

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 impact tree rooting, availability of water and nutrients, availability of oxygen, and water movement through the soil. Negative impacts that can occur during forest management activities include compaction, puddling, rutting, and displacement. These disturbances can be caused by movement of heavy equipment during timber harvesting activities if the harvest occurs during times of the year when the soil is wet or if harvest machinery is not appropriate for the type of forest ground. A consulting forester may require forest harvests to occur during dry or frozen ground conditions and may even require low pressure tire or tracked equipment, depending on the site conditions.

SOIL COMPACTION

Soil compaction is the increase in soil density resulting from heavy loads applied to the soil surface. Compaction results in the loss of pores (air gaps) in the soil structure. The number and size of pores in the soil directly affect air and water movement in the soil. Having large pores in the soil is particularly important in regulating the rates of water and air movement.

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.

Limiting soil compaction is important because it can decrease the rate of tree growth (Pritchett 1979, p. 444). Compaction leads to a lack of oxygen and the build-up of carbon dioxide and other toxic gases in the soil which can cause damage to tree 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 toxic gasses. Compaction further affects root growth by making it more difficult for the roots to grow through soil. It decreases pore space, which reduces the rate of water movement into the soil so that less moisture is available for plant growth. Also, compaction causes more rainfall to flow overland, which can increase erosion and sedimentation.

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." Soil compaction is a concern on soils with higher amounts of organic matter, more so than sandy soils. Loggers can reduce the amount of soil compaction by using low pressure tires, using tracks on their tires or placing harvested tree tops along their paths to reduce soil compaction. Professional foresters are aware of the conditions that cause soil compaction, and will write specific language into a timber sale contract to ensure contractors minimize soil compaction issues. Landowners should also be proactive and discuss issues such as soil compaction with your forester.

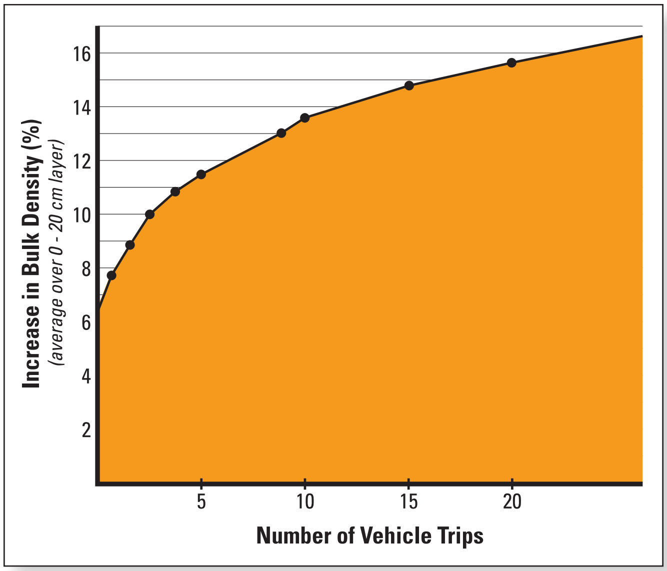


Figure 7-2: Effect of vehicle trips on soil density. *(Adapted from Froehlich et al., 1980)*

Figure 7-3: Tracked vehicles or vehicles with oversized tires like the one pictured above, have lower ground pressure and can help limit the negative impact on soils that compaction or rutting would cause.

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. 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 nonnative 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.

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 compacts pores which lowers oxygen levels and limits water movement.
- Rutting disrupts natural surface water hydrology by damming surface water flows, creating increased soil saturation up-slope from ruts. Alternatively, ruts that run parallel to a slope can divert water flow away from a site, drying or draining it. This is extremely evident in organic soil wetlands where 90 percent of the horizontal water flow takes place in the top 12 inches of the soil. Ruts can also concentrate water movement increasing 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 layers 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 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 most commonly associated with roads and skid trails (see Chapter 12: Forest Road Construction and Maintenance). Erosion seldom occurs on areas with established vegetative cover or flat areas. Care must be taken to protect bare soil, especially during harvesting practices that removes forest cover on steeper slopes (e.g., coppice, overstory removal, seed tree, etc.). Extra care should be taken on long slopes or slopes greater than 10 percent. Sometimes, large, dense infestations of certain nonnative 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 water levels 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 in uptake of water by trees. For example, many ash stands occur in these high water table areas. Care should be given when conducting harvests in these areas to not remove all the overstory trees, as that will create a rise in the water table and may make it difficult to regenerate new trees in these areas.

PROTECTING SOIL PHYSICAL PROPERTIES

- **Compaction and Rutting:** Finer textured soils such as silt and clay soils or soils shallower to bedrock are more susceptible to compaction and rutting. It may be important to adjust harvest timing and techniques to protect these soils. Coarse textured and fast draining soils may not require some of these considerations and it may be possible to harvest these sites year round, but conditions and sites can vary. Care should still be used to evaluate all soils prior to harvesting to determine if adjustments should be made.

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

The timing of forest management activities, type and placement of infrastructure (roads, landings, etc.), selection of equipment, and operating techniques are all critical factors in avoiding effects to the soil resource. It is important to avoid operating heavy equipment on a site when adverse soil impacts are likely, and to limit harvest operations on a site to the smallest area possible. Limiting operations to drier seasons or to frozen ground conditions can limit impacts to the soil. Spring and summer, following heavy rains, and in the fall just before freeze up are times to avoid as saturated soil conditions can be present and should be avoided. On sensitive soils during saturated conditions, management activities could result in heavy damage.

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.

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.

- **Erosion:** Erosion can be a problem on areas where there is a lack of vegetative cover, such as on roads or skid trails. Erosion can lead to soil losses and sedimentation of streams and other water bodies. Techniques for limiting soil erosion and sedimentation from roads are discussed in Chapter 12: Forest Road Construction and Maintenance.

- **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).

POSITIVE IMPACTS FROM SOIL DISTURBANCE

As a landowner and/or manager, there are a lot of considerations when managing land and establishing a timber harvest. While this chapter has provided important aspects to consider in order to protect soil, not all disturbances are negative. It is important to note that in some instances disturbance is needed to help promote certain species. For example, soil scarification is a common practice used to help promote oak or birch on a site. Soil scarification is the exposing of mineral soil, often accomplished by running a bull dozer with a blade across the surface of the soil. Some tree species do better when mixed with mineral soil, which is why scarification is important. Root raking is another tool used in combination with a bull dozer that has shown to be successful in promoting oak regeneration.

Contacting a professional forester who works in your region and is familiar with your soil type will be able to best navigate what practices should be avoided, and what types of soil disturbance practices may actually help achieve your objectives.

Characteristic 2: Chemical Characteristics of Soil and Potential Impacts

Soil chemical properties include nutrient availability and pH of the soil. Soil chemical characteristics are influenced by many factors including soil origin, soil texture, 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).

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 contributions from the atmosphere (Kolka et al. 1996). Nutrients are lost from a site through leaching, volatilization (conversion to a gas) in the case of nitrogen, and removals in harvested wood. If nutrient losses are greater than nutrient inputs over the time period it took to grow the forest, nutrient depletion can occur (Johnson et al. 1988). The likelihood of nutrient depletion is greater with shorter rotations, when working with nutrient-demanding species, or when whole-tree harvesting occurs.

The nutrient availability of sites in Wisconsin varies widely, depending on the origin and the depth of soil. For example, one soil may contain 50 times the amount of calcium in the rooting zone than another soil formed from a different parent material (Grigal and Bates 1992). Some soils 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 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).

Wetland soils also have a unique nutrient status. These soils are saturated to a zone near the surface, and mineral weathering is slowed by a lack of oxygen availability in the soil. Many of these soils receive nutrient inputs only from runoff, and are particularly susceptible to nutrient losses due to harvesting, especially 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 traditional harvesting. 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. 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 availability.

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.

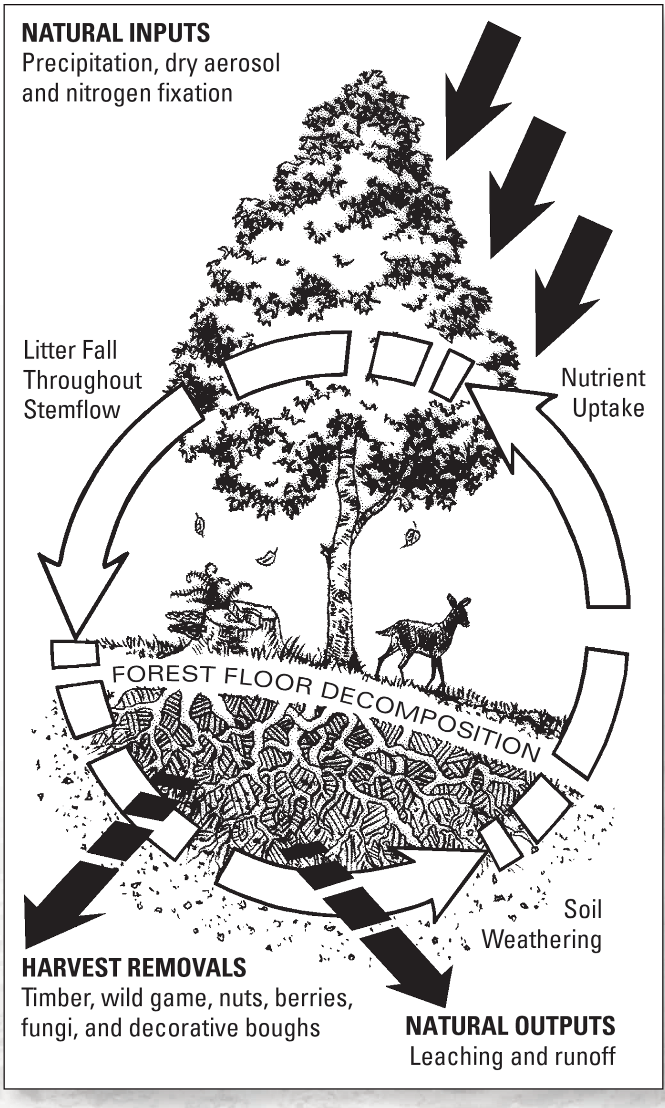


Figure 7-7: Nutrient Cycling (Adapted from Figure S-2, pg. 17, Forest Soil Productivity, Voluntary Site-level Forest Management Guidelines: Sustaining Minnesota Forest Resources)

Seasonal movement of nutrients within the tree itself inform a decision about whether to harvest in the summer, when the foliage of deciduous trees would be removed during whole-tree harvests, versus harvesting in winter. In fall, nutrients move 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 traditional 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.

NUTRIENT-RETENTION STRATEGIES

- Retain or redistribute slash (tops and limbs) on the site.
- Avoid whole-tree harvesting on nutrient-poor sites.
- Avoid whole-tree harvesting of nutrient-demanding tree species.
- Avoid shortened rotations. Check the Wisconsin DNR *Silviculture Handbook* for recommended rotation lengths.

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.

WISCONSIN'S FORESTLAND WOODY BIOMASS HARVESTING GUIDELINES

Wisconsin's Forestland Woody Biomass Harvesting Guidelines focus on the sustainable harvest of woody biomass from forested areas within the context of generally accepted forestry practices, and provide considerations and recommendations applicable to stand and site-level management. These guidelines, when applied in concert with other forest management guidelines (*Wisconsin Forest Management Guidelines*, (FMGs), *Wisconsin Forestry's Best Management Practices* (BMPs) and the *Wisconsin DNR Silviculture Handbook*), address potential impacts of increased biomass harvesting on biodiversity conservation, soil nutrient depletion, physical properties of soil, and water quality. The objective is to provide guidance to forest resource managers, loggers, equipment operators, contractors, and landowners in Wisconsin, and to facilitate operational analysis and informed decision-making regarding the harvest of woody biomass from forestland.

Traditional timber harvests generally remove woody material greater than four inches in diameter from the bole of a tree for use in traditional forest products, while smaller material is left on site. In "biomass harvests," the entire above ground portion of a tree may be removed, including trunk, branches, bark, and leaves or needles. The harvest of fine woody material from forests results in increased removals from a site as compared to traditional timber harvesting, and a higher level of nutrient export. While bio-energy is the typical use for this material, it is important to note that these guidelines apply to any sale of fine woody material regardless of whether the product is energy production.

Wisconsin's Forestland Woody Biomass Harvesting Guidelines can be found on the Council on Forestry website at: ***https://councilonforestry.wi.gov/Pages/WoodyBiomass/Overview.aspx***.

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

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. Tree species that rely on mycorrhizal fungi include pine, spruce, fir, maple, ash, birch, beech, oak, basswood, black walnut, black cherry, and willow. 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.

Infiltration of moisture into the soil is aided by dense ground vegetation and thick forest floor, or duff layers, which 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 nonnative 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 nonnative 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 7-12 and in Chapter 8: Threats to Forest Health.)

"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.

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.

Figure 7-9: Buckthorn, a nonnative 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. These different site conditions include soil types formed from different parent materials, varying topography, and with different management histories.

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.

Figure 7-10: 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

Certain types of soil disturbance can encourage an invasion of nonnative 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: Threats to Forest Health 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.

RESOURCES FOR ADDITIONAL INFORMATION

SILVICULTURE HANDBOOK

Silviculture Handbook. Wisconsin Department of Natural Resources, Publication Number 2431.5, Madison: Wisconsin Department of Natural Resources, 2010.

SOILS LAB ANALYSIS

University of Wisconsin Soil and Plant Analysis Labs are located in Madison and Marshfield.
uwlab.soils.wisc.edu

WEB SOIL SURVEY MAPPING PORTAL

The NRCS Web Soil Survey provides soil data and information produced by the National Cooperative Soil Survey in an easy to use interactive web mapping application.
websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

WISCONSIN'S FORESTLAND WOODY BIOMASS HARVESTING GUIDELINES: FIELD MANUAL FOR LOGGERS, LANDOWNERS, AND LAND MANAGERS

Wisconsin's Forestland Woody Biomass Harvesting Guidelines: Field Manual for Loggers, Landowners, and Land Managers. Wisconsin Department of Natural Resources, Publication Number FR435-2009, Wisconsin Department of Natural Resources, 2009.
https://councilonforestry.wi.gov/Pages/WoodyBiomass/Overview.aspx.

WISCONSIN NATURAL RESOURCES CONSERVATION SERVICE (NRCS)

Published soil survey reports for most Wisconsin counties are available through your local NRCS or county Land Conservation Department offices. Soil survey reports include:

- Detailed soil maps on an aerial photo background
- Descriptions of the soils
- Soil use and management information
- Recreational development information
- Soil property and interpretation information in table format

More information about soil survey reports is available at:
www.nrcs.usda.gov/wps/portal/nrcs/main/soils/survey.

WISCONSIN DEPARTMENT OF NATURAL RESOURCES
NOTICE OF FINAL GUIDANCE & CERTIFICATION

Pursuant to ch. 227, Wis. Stats., the Wisconsin Department of Natural Resources has finalized and hereby certifies the following guidance document.

DOCUMENT ID

FA-20-0005

DOCUMENT TITLE

Wisconsin Forest Management Guidelines

PROGRAM/BUREAU

Forest Economics and Ecology, Applied Forestry Bureau

STATUTORY AUTHORITY OR LEGAL CITATION

S. 823.075, Wis. Stats. & NR 1.25, Wis. Admin. Code

DATE SENT TO LEGISLATIVE REFERENCE BUREAU (FOR PUBLIC COMMENTS)

2/10/2020

DATE FINALIZED

4/6/2020

DNR CERTIFICATION

I have reviewed this guidance document or proposed guidance document and I certify that it complies with sections 227.10 and 227.11 of the Wisconsin Statutes. I further certify that the guidance document or proposed guidance document contains no standard, requirement, or threshold that is not explicitly required or explicitly permitted by a statute or a rule that has been lawfully promulgated. I further certify that the guidance document or proposed guidance document contains no standard, requirement, or threshold that is more restrictive than a standard, requirement, or threshold contained in the Wisconsin Statutes.

Carmen Hardin — March 27, 2020

Signature — Date