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A Loblolly Pine
Management Guide

Managing Site Damage From Logging

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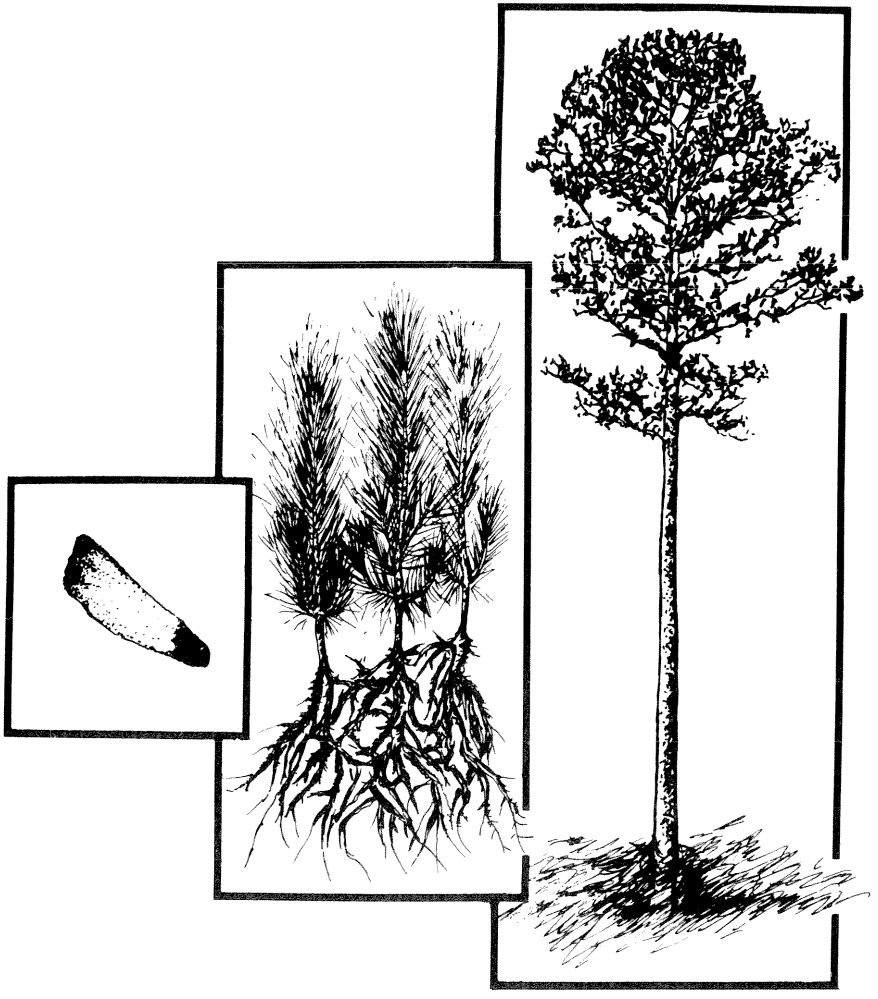

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ABSTRACT

Serious damage to forest sites during logging can be avoided through careful planning of logging, preparation of the site for logging, and close supervision of the work. Losses in productivity caused by compaction can be largely restored by cultivation and fertilization.

Keywords: Pinus taeda, site productivity, fertilization, drainage, trafficability, soil compaction.

Logging operations can seriously damage forest sites by destroying soil structure, blocking drainage, damaging seedlings, and transporting nutrients. As much as two-thirds of a logged area can be damaged, and costs in lost productivity can be $60 to $90 per acre on Coastal Plain sites. Growth of seedlings, for example, may be halved by soil compaction (table 1). Historically, the blame for this damage has been placed on logging contractors and their employees, but much of the damage can be prevented by a land manager through careful planning of the sale and full preparation of the site for the logging operation. Careful control is then needed during the logging operation. Damaged sites can be largely restored to productivity by cultivation and fertilization, but the less damage done to a site the less special site preparation is needed.

Preparing for the Timber Harvest

Methods for minimizing site damage prior to logging include preparing the timber stand for cutting, determining when to log, laying out skid trails, and choosing the proper equipment. Planning before the sale allows the manager to understand the hazards of logging a site and to devise practices suited to the site.

Table 1.--Dry weights of 1-year-old loblolly pine seedlings grown on soils of various textures with and without compaction

Soil treatment	Tree component weight		
	Shoot	Root	Total
	- - - - - Ounces - - - - -		
Not compacted	12.13	3.70	15.83
Compacted	6.49	2.33	8.82

Site Preparation

Foresters are accustomed to thinking of site preparation as a silvicultural practice designed to improve growth of seeded or planted trees. Site preparation for logging may, therefore, seem foreign. The primary objective here is to reduce damage to the site during logging, and this objective can be met in two ways. First, visibility can be improved. This step permits the skidder operator to see well and avoid obvious wet spots. Second, drainage of wet areas can be improved. In addition to facilitating logging and reducing site damage, these practices often provide silvicultural benefits.

Prescribed burning is the most economical way to improve visibility on a logging site. This technique is especially suited to even-aged pine stands, in which hardwood invasion is a constant problem. Control of hardwoods throughout the pine rotation ensures an open site and reduces site preparation costs. Timber buyers are willing to pay more for stands that are free from brush and understory growth. This factor alone may offset the cost of prescribed burning.

In wet conditions, logging equipment can leave deep ruts. The compacted soil is difficult to prepare for planting, but without intensive site preparation tree growth will be poor.

In open parklike stands, machine operators can see the ground and avoid many low, wet places that would otherwise be masked by thick underbrush. It is also easier to locate skid trails to the advantage of both the logger and stand manager in such stands. Thus, open stands often bring better prices than brushy ones. Brush may be beneficial on some very wet sites, where small stems serve as a mat for support of logging equipment, but such sites seldom carry a fire. A forest floor that has built up over a number of years may contain a major portion of the site's mineral nutrients (nitrogen, phosphorus and calcium). During logging, skidders displace the forest floor and some topsoil, leaving skid trails poor in nutrients and surface mineral soil. This process often can be prevented by prescribed burning, which reduces 80 or 90 percent of the forest floor to ash and renders the nutrient layer less susceptible to movement by logging equipment.

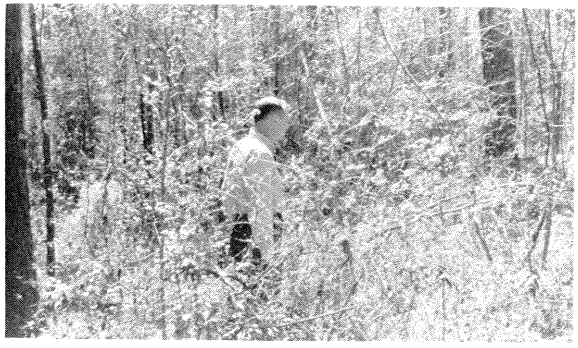
Herbicides may be a satisfactory substitute for prescribed burning where fire is likely to lower the quality of the harvested stand, where the forest floor will not carry a fire, or where fire may increase soil erosion. The herbicide to be used and the method of application will depend on target species, available facilities, and cost savings expected from opening up the stand for harvest. Federal and State regulations must be followed in selecting and applying a herbicide. Possible effects of herbicides or fire on other resources such as wildlife should also be considered. Suppression of unmerchantable hardwoods and understory vegetation with fire or herbicide frequently requires repeated treatment over a period of 1 to 3 years. These treatments should be planned well in advance of the actual cutting.

Drainage

On wet, flat areas, artificial drainage may be needed to facilitate logging as well as regeneration. A ditch system should lower the water table to 12 to 18 inches below the surface on mineral soils and to about 24 inches on organic soils. Draining of large areas is costly and requires heavy equipment; small areas can frequently be drained with farm equipment. Drainage of wetlands is also subject to regulation by government agencies, and permits may be required.

Season of Logging

In much of the Southern Coastal Plain, the water table is at or near the soil surface during some portion of the year. In other seasons, the water table may be quite deep and the soil is hard enough to support the heaviest of equipment. It is common sense to avoid logging of such sites when the water table is high. Sometimes, however, stumpage prices are somewhat higher during the wet season because relatively little timber is accessible. In such cases, the manager of a tract must



A Understory vegetation can complicate logging by obstructing vision of operators. It also hinders regeneration.

B Prescribed burning opens stands for logging, increasing the value of timber, reducing site damage, and aiding in regeneration.

C Where burning is impractical, injection with herbicides may be desirable for opening a stand.

decide whether the higher stumpage price will offset the additional costs of repairing the site or the lost growth caused by logging damage.

In steep terrain, soil compaction and shallow water tables are seldom problems. Here, erosion during heavy rains is the primary concern. Thus, in hilly areas it is best to plan logging operations for periods when heavy rains are unlikely.

Site Layout

Some site damage during logging often is inevitable, but careful location of skid trails can concentrate soil damage on limited areas, thereby minimizing repair costs. The greatest concern is disruption of drainage. Logging trails can dam water, change a drainage course, or leave a ditch on a slope where gully erosion can begin. Correcting these problems can add to site repair costs. The best solution is a careful layout of logging trails prior to harvest. From the driver's seat of a skidder, small changes in land elevation are impossible to see, but on the ground after heavy rains, drainage patterns are easily recognized. Skid trails can be laid out to improve drainage on poorly drained flat areas. On excessively drained sites, it is often desirable to skid along contours to create drainage barriers and slow runoff.

Soil Maps

County soil surveys, which include descriptions of drainage, trafficability, and other soil characteristics, give insight into how and when equipment can be used with the least impact. Frequently, soil maps can be used to locate roads, log decks, and skid trails on the least productive soils, leaving the most productive sites free of logging damage. Area conservationists with the Soil Conservation Service can help with soil mapping. Armed with soil maps and a tentative

operating plan, the manager and the logging contractor should carefully inspect the site. Depressions, gullies, ditches, and other features that are not noted on the soil map should be flagged so that appropriate changes can be made in the layout of log decks and skid trails.

The potential for damage of a site by logging equipment is variable, and appropriate actions depend upon local conditions. In general, however, it is best to place log decks at the tops of ridges in steep terrain. When logs are skidded uphill, skid trails fork as they go downhill. Thus, drainage water on them is dispersed rather than concentrated.

Soil Properties

Soil texture provides an index for selecting the seasons when logging damage will be minimized. Well-drained sandy soils are damaged less in wet than in dry seasons because sands are very resistant to compaction but become unstable and are likely to rut when dry. In contrast, silty, loamy, and clayey soils are more subject to rutting when wet.

A less tangible factor to consider is site fertility. In general, the higher the site fertility the less the effect of soil compaction and puddling in the next rotation. Nevertheless, it seems wise to minimize damage on the best sites.

Roads, Log Decks, and Skid Trails

The layout of roads and skid trails must do the least harm to the site while meeting the requirements of the logging operation. Normally, rubber-tired skidders can operate from 500 to 1,000 yards from a log deck, but track-type vehicles can be used only up to 600 yards from the deck. Yarding distance for cable rigs is about 300 yards.

Ditching may be required before logging some areas. The ditch size and equipment needed depend on the local conditions.

Skidding across a drainage is bound to cause damage.

In addition to the capacity of the specific equipment, size of logs skidded and tree density are part of the formula. Some basic guides in locating skid trails are:

- In steep terrain, do not run trails downhill where they will concentrate water and cause erosion.
- Concentrate trails, where possible, to minimize the area affected.
- Do not cross stream channels or excessively wet areas.
- If a choice is available, locate skid trails on sandy rather than clayey soils, which are more susceptible to compaction.

In this publication, we make no attempt to discuss road construction or log-deck design, which are adequately described in many references. Here, however, are some useful guidelines on deck location.

- Locate decks to avoid skidding across wet, unstable soils and to limit length of skid trails.
- Avoid steep slopes; use natural breaks in the terrain such as benches or moderate slopes.
- Avoid creeks or obvious wet areas.
- Place decks and trails no closer than 130 feet from any stream channel to prevent sedimentation of the stream channel.

Choosing Equipment

The type of logging equipment that is used is a primary determinant of the amount of logging damage that will be sustained. A typical rubber-tired skidder puts a pressure of 20 pounds per

square inch on the soil. A crawler tractor exerts about half that pressure, and wide flotation machines may exert only 5 pounds per square inch on the soil. Finally, a cable-logging setup lifts the logs from the ground and exerts no pressure. The amount of compaction damage sustained is roughly proportional to the pressure exerted on the soil.

Damage also depends upon the type of soil and its wetness. In this brief treatise, it is impractical to describe all the combinations of equipment, soil, and moisture conditions that may be encountered. Instead, we have developed a hazard index by which a site can be classified according to the soil texture (sand, silt, or clay) and the depth to the water table in the wet season (fig. 1). The rating is designed to give an indication of the probability of damage during the wet season. During dry periods, most soils dry sufficiently to support logging equipment.

Frequently, however, cruising and timber-sale planning are done during the dry season. Since our hazard rating scheme requires an estimate of the depth to the water table in the wet season, we offer a simple method for estimating that value from measurements taken in the dry season. Using a soil auger or a spade, dig a hole to the depth where mottling occurs. "Mottling" is a soil scientist's term for a distinctive change in color. Whereas the soil above the mottling is likely to have reds in its brown, mottled soil contains blotches of gray, lighter brown, and yellow. This color change is caused by the presence of water for extended periods.

Figure 1 guides the selection of appropriate logging equipment. The objective is to choose equipment that will keep the plotted pressure exerted by the vehicle and the depth to wet-season water table below the diagonal line for your particular soil type. The widths of tires and tracks strongly influence the pressure placed on the soil

so it is best to get a specific value for the equipment that is available in your area.

On steep slopes with erosive soils, the land manager may choose to permit only cable-logging equipment. On flat areas in wet seasons, cable logging is also an option, but so is light flotation track equipment, which exerts very little pressure on the soil.

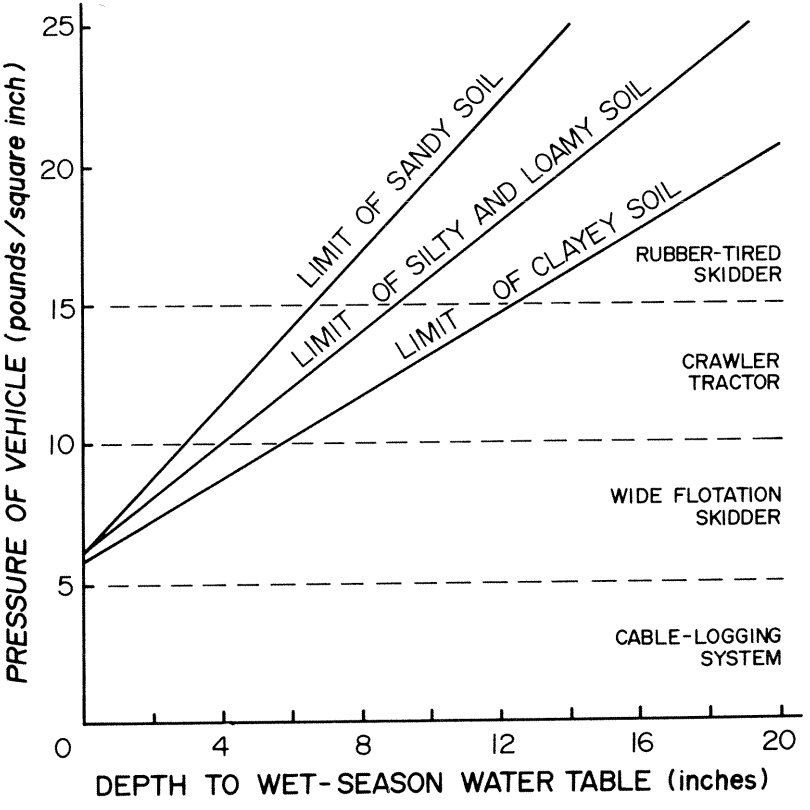


Figure 1.--Hazard of rutting during wet-season logging.

Control Over Logging

Site preparation and planning are futile without close control over the harvesting operation. Logging should be monitored to see that the contractor is using the equipment agreed to in the sale. Tires and tracks on equipment should be inspected. Worn, underinflated or improperly installed tires do not have the required traction and cause rutting and other soil disturbance. Moreover, they add to the cost of logging, require more fuel, and cause harder wear on tractors.

The final responsibility for preventing or at least reducing site damage rests with the tractor operator. Responsible machine operators are an absolute necessity. Reckless operation of tractors not only damages the site but also is hard on equipment and represents a work safety problem. Close supervision by the logging contractor and land manager is indispensable.

With most kinds of equipment, poorly drained sites are sometimes too wet to log without damage. The point at which logging should stop must be specified in the subcontract. The limitations of soil wetness depend on the internal drainage of the soil and the equipment used. Well-drained to excessively drained soils may require few limitations except on some steep slopes and unstable soils. As drainage deteriorates, the sensitivity of the site to compaction and puddling increases. Puddling is a loss of soil structure caused by working in wet conditions. Compacted or puddled soil loses its ability to provide air to plant roots. In general, sensitivity of soil to compaction and puddling increases as texture varies from sandy to clayey soil and as soil organic matter decreases. In all cases, soil becomes more sensitive to physical forces as the moisture content increases.

When is it too wet? That depends on the equipment used, the experience of the logger, and

the requirements imposed by the land manager. It is probably too wet when skidders produce ruts over 10 inches deep in one or two passes or when the soil has reached its "liquid limit." When a handful of soil is squeezed and water drips out, the soil has passed its liquid limit and will not support traffic. The susceptibility of a soil to compaction again is variable, and a knowledge of local soil conditions is needed.

Most compaction of a soil occurs during the first pass of equipment, and two or three additional trips will compact it about as much as the vehicle is capable of compacting it (fig. 2). For this reason, most land managers favor concentrating skid trails to limit the area affected by logging.

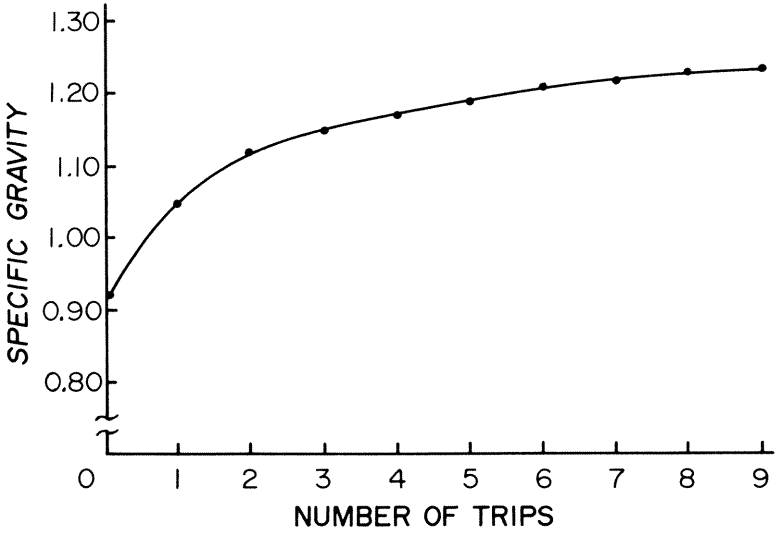


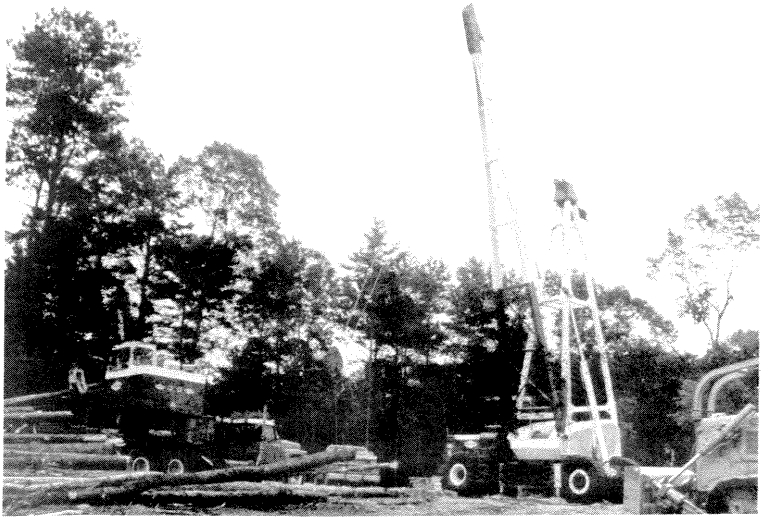
Figure 2.--Relationship of bulk density of surface soil to number of vehicular trips with 10 pounds per square inch of ground pressure.

Note: Most compaction occurs during the first three passes.

A

B

C



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Logging equipment ranges widely in its effects on the soil: A, Wide tires on rubber-tired skidder reduce soil pressure; B, track-type hauler exerts less pressure; C, wide track; even less; and D, cable equipment exerts none at all.

The following guides are suggested for management of a logging operation:

- Be sure that proper equipment is used, that equipment is in proper repair, and that it is being used correctly.
- Do not log clayey and loamy soils when water can be squeezed from them by hand.
- Do not log if two or three passes leave ruts 10 inches deep.
- When water seeps into ruts on one-third to one-half of a skid trail, logging should be halted.

Repairing Damaged Areas

Before any repair can be prescribed, the type and amount of damage must be known and understood. The most serious types of soil damage from logging are compaction, erosion, and drainage impedance. Repair must be designed to alleviate the damage and it should be concentrated where the damage is most severe, such as on logging decks.

The equipment used to repair a site is often as heavy as the logging equipment that caused the original damage. Thus, the tillage operation can increase compaction under adverse conditions. Repair should be attempted only when the soil is dry enough to support the equipment and when the tillage will thoroughly break up the soil. During logging it may be necessary to operate the equipment under less-than-ideal conditions, but there is never a reason to attempt repair of the site unless the soil conditions are acceptable.

Soil Compaction

Even when soil moisture content is below the liquid limit, some compaction will occur on skid

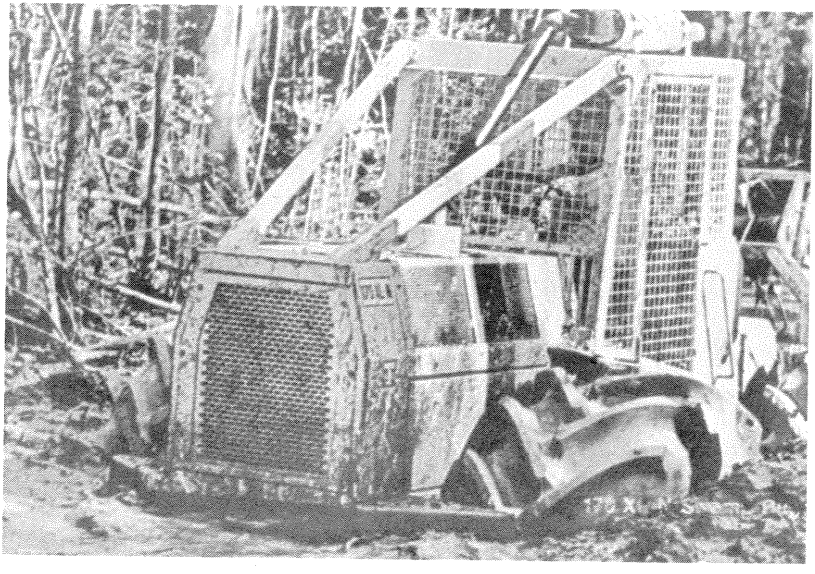
trails and log decks. These areas should be treated to avoid serious loss in productivity. The most effective treatment is tillage coupled with fertilization (table 2). The tillage equipment should run only deep enough to break up the compaction. Deep compaction, caused by heavy equipment on wet soils, may require specially modified equipment. Bedding machines commonly used in site preparation can be fitted with a ripping shank at the center to loosen soil to a depth of 18 inches, which is adequate for penetration of pine taproots. For this treatment to be effective, however, the soil must be fairly dry down to the depth of the shank. Other practices must be considered on soils that are normally wet much of the year.

Table 2.--Heights of loblolly pines 4 years after planting on a compacted skid trail that was bedded and fertilized[1]

Treatment		Tree height on--	
Bedding	Fertilization	Compacted skid trail	Uncompacted area
	Pounds per acre	- - - - Feet - - - -	
None	None	5.5	6.7
	200-50-100	8.1	8.6
Bedded	None	9.6	11.3
	200-50-100	12.5	11.6

[1]Soil is a poorly drained Bethera Series in the Coastal Plain of South Carolina.

Left rear tire is installed **backwards, reducing** traction and increasing site damage.



Logging when it is too wet **strains equipment** in addition to damaging the site.

Nutrient Loss

The application of fertilizer is a practical way to offset the effects of physical damage to the soil, especially on logging decks and skid trails. Particularly on wet or compacted soils, the application of phosphorus appears to allow the plant to overcome restricted aeration. The fertilizer does not completely replace good aeration but represents a relatively inexpensive alternative to intensive mechanical treatments on wet sites. On sites that remain too wet to repair mechanically, fertilization may be the only alternative. The method of application is unimportant. Between 200 and 500 pounds per acre of triple super-phosphate (0-46-0) or diammonium phosphate (18-46-0) are adequate. In all but poorly drained clay soils, nitrogen as well as phosphorus should be added.

Soil Erosion

Erosion can be a problem on relatively gentle slopes if the soil is compacted, laid bare, or left with ruts running uphill and downhill. Sheet erosion should be prevented by tilling the site to reduce compaction and then revegetating the area as quickly as possible. Ditches and ruts should be filled to prevent the formation of gullies. On sites with bare soil subject to erosion, nitrogen is needed as well as phosphorus because the original nitrogen was concentrated primarily in the forest floor and surface mineral soil. In general, 300 pounds per acre of mixed fertilizer such as 10-10-10 will speed revegetation.

In addition to fertilizer, a cover crop is often needed to prevent erosion of bare soil. Quick cover can be obtained by seeding a fast-growing species, such as ryegrass, in early fall or spring along with a perennial species that will vegetate the site until woody plants become established. Because of its aggressiveness, the ryegrass should not be seeded at a rate of over 5

pounds per acre. The perennial grass should be seeded at a heavier rate, 50 to 60 pounds per acre of tall fescue or 40 to 50 pounds per acre of Bermuda grass. Depending on site and climate requirements, other grass species may be desirable.

Drainage

The drainage of a site can be considerably disrupted during logging, and displaced soil may create dams. Such conditions can be alleviated by disking or bedding during site preparation. Even on sites that had good internal drainage before logging, deep rutting may restrict lateral flow of water in the soil, raising the water table to the point where planted trees cannot survive. Bedding may be required on these sites to raise the seedlings above the new water table.

Rough Areas and Tree Regeneration

Leveling the ground surface with a dozer blade may be a practical alternative on heavily disturbed sites, such as skid trails and log decks, if compaction is not a problem. If the site is to be regenerated naturally, special consideration should be given to these areas. The skidding and repair operations in these areas will have destroyed the seedlings already there. These areas should either be planted or direct-seeded to ensure a uniform stand. Local guidelines for establishment of the species used should be followed.

The following guides are suggested for repairing damage to soils in log decks and skid trails.

- Rip (subsoil) and bed areas that are compacted or puddled.
- Apply phosphorus or nitrogen and phosphorus fertilizer.

- Where slopes exceed 6 percent, fertilize and seed with grass before planting trees.
- Clear blocked drainages.
- If a natural regeneration system is used on the area as a whole, trails and log decks may have to be planted with seedlings.

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