

## Logging



# Road Construction on Woodland Properties

J.J. Garland

You, the woodland owner or manager, are probably aware of the significance of roads to your property. Before you construct a road, you must consider the woodland management objectives it will help you accomplish and the necessary road design requirements. Additionally, you must anticipate road maintenance and incorporate this into design and construction phases. You will find vital background information on planning, designing, and maintaining woodland roads in the list of suggested readings at the end of this publication.

After you carefully plan your roads, you must decide to do the work yourself, or contract out the construction. Whether you decide to contract the road or build it yourself, you should review the roadbuilding process.

This publication offers information about road construction. It describes different capabilities of roadbuilding machines, road subgrade compaction (compressing the earthwork on the road surface), and drainage feature installation. It also addresses some special problems you may encounter during construction.

### Road construction options

You have several options for building roads on your woodland property: You can hire a contractor to do *all* or *part* of the work; you can do the construction with equipment you have available; or you can rent or lease equipment. Each of these options depends on your knowledge and skill in road construction.

Before settling on a particular option, you must carry out several important steps in road design (see EC 1118 and EC 1137). If a machine operator starts constructing the road without design information, the economic and environmental consequences could be disastrous.

Road construction requires that you notify the Oregon State Department of Forestry and, in some cases, secure approval from the forest practices forester before beginning construction.

**Contracting for road construction.** Contractors have different capabilities: some have small equipment for uncomplicated jobs; others have large equipment for all roadbuilding conditions.

Your task is to provide contractors with design information and to supervise construction

activities. With a solid understanding of the construction process, you are in a better position to supervise road construction.

You may wish to build or rebuild road sections yourself, leaving those that are most difficult for a contractor. However, it is usually more economical to contract for a complete road project. Even uncomplicated road sections may take days of work with the small equipment usually available to woodland owners. A contractor with larger, more appropriate equipment might be able to do the work in a short time.

Selecting and supervising a road construction contractor can be a taxing procedure. Yet, your supervision is essential to achieve the planned and designed results. The list below identifies some common business practices for dealing with contractors.

- Contact sources for potential contractors: your county Extension forester, offices of the Oregon State Department of Forestry, forestry consultants, contractor associations, and referrals from other woodland owners.

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- Obtain references from potential contractors and check with past clients.
- Use a written contract and make it as specific as possible.
- Check the contractor's performance bond, insurance coverage, forest practices notification, and fire preparedness. Remember, you are ultimately responsible for what happens on your property.
- Conduct an initial review with the contractor and the contractor's key personnel on the proposed road location before beginning operations. Use your design information to guide your review.
- Find out who will represent the contractor when the contractor is absent from the job.
- Make frequent, unannounced inspections; however, approach the working area with caution so your presence does not cause a safety problem.
- Withhold a portion of the periodic payments (10%), to help assure contract compliance. Include this in the contract.
- Plan to meet with the contractor before construction encounters likely trouble spots, such as stream crossings.
- Make yourself available for road design changes or contract modifications. If the contractors cannot reach you, they often will proceed without your advice.
- Work with the contractor to achieve a mutually satisfactory result. Contractors who meet your needs can then use you as a reference.

The provisions in the contract are the starting points for inspecting roads under construction. During contract supervision, make sure the roads are excavated to the required width and grade. Check culvert locations and installations and make sure excavated material and debris are placed away from the stream.

See that fills have been compacted properly and are stable for road use. Finally, do not allow the contractor to move the equipment from the job until all work is satisfactory.

**Construction by woodland owners.** You may have sufficient skills and equipment to build your own roads. Also, some roads you used in the past may simply need to be rebuilt and graded (reshaping the travel surface, usually with a blade) to be usable for log hauling. Whatever your situation, you will need a plan and road design information. Resist the temptation to jump on the machine and begin work until you have thought through the entire project.

Roads that woodland owners can build usually have most of the following characteristics:

- The proposed road is on slopes that are less than 40% steep.
- The road requires a minimal amount of excavation, and the fills do not require a big compaction effort.
- Stream crossings are small and do not require special features, such as large culverts or bridges.
- There is no rock to excavate and no need to blast rock or large stumps.
- A technical reviewer, such as a forester or forest practices forester, has determined that the road construction would not result in soil or water damage.

There are common problems that occur when woodland owners attempt roads beyond their capabilities. These include roads that are built too narrow for log truck traffic and roads with alignment so winding it hinders truck travel time—especially on sharp and narrow curves.

Woodland owners with limited construction experience may have problems with wet spots or springs in the road. Some fail to construct adequate drainage features, such as ditches, crossdrains, and stream crossings.

In addition, if the trees and vegetation are not removed from beyond the top of the cut slope, they often fall into the roadway or plug the ditch.

Road intersections often are trouble spots: The intersection approach may not match grades or accommodate the direction of

travel by loaded log trucks. This listing is not to dissuade you from constructing your own road, but to help you avoid such problems.

**Renting or leasing equipment.** If you are skilled and experienced at operating construction equipment, you may be able to rent or lease equipment to help build your roads. If you own equipment that is similar to road construction equipment, but lacks the capacity for heavy work, renting or leasing may be an attractive option.

Most of the equipment available at home and garden rental outlets is too small for road construction, but heavy equipment dealers and construction rental sources have a full range of suitable machines. The rental rate is given by the hour, day, week, or month. Payments are required in advance and usually do not include the cost of moving the machine from the equipment lot to the property and back.

Rental machines are usually used machines. You are responsible for breakdowns attributed to operator abuse; the rental firm will cover other breakdowns.

You provide expendable items, such as fuel, lubrication, and filters. You also provide your own insurance coverage.

Leasing machines is less common than renting them. A lease/purchase option may be available and may be carried by the equipment dealership or a third-party financial institution. New machines are most frequently leased; they are covered by the manufacturer's warranty for 1 year (excluding operator abuse).

Straight lease arrangements involve a series of equal payments at about the same rate as rental rates. Lease/purchase arrangements vary with the equipment dealership; they may or may not include insurance. The lease does not cover expendable items.

## The roadbuilding process

Woodland roadbuilding typically follows a standard pattern of activities—although many variations are possible. It begins after

road reconnaissance, design, and field layout. Follow the procedures listed below to build your road.

**Right-of-way logging and the pioneer road.** Fell the timber in the road right-of-way, buck it to log lengths, and deck (pile) it where you can load and haul it away once the road is built.

You build a *pioneer road* by excavating the small width a logging vehicle (crawler tractor) needs to skid the logs to the decking area. The pioneer road must service the logging function as well as be in the correct position for the excavation equipment.

On gentle terrain (side slopes less than 40%), the position of the pioneer road is less critical than on steep terrain. On steep terrain, it is sometimes difficult to find locations for log decks that will not be in the way of excavation activities. Yet the decks must be within 10 to 15 feet of the final road surface to make them accessible to loaders.

The pioneer road provides the first indication of unforeseen problems with the road location. Hidden rock, springs, and poor soil are often discovered during pioneer road construction. When you encounter such problems, it is a good practice to solve them before you proceed with further excavation.

When you encounter small distances of rock, shift the road location outward to avoid blasting the rock. Plan extra drainage features for areas where springs occur. And, if possible, replace the poor quality soil with better construction material, especially in critical fill areas.

**Clearing and grubbing.** Remove stumps and other organic debris from the roadway. It is especially important to avoid mixing this material into fills.

The excavation machine usually removes stumps. Some crawler tractors are equipped with a stump splitter that backs a wedge-shaped "stinger" into the stump to break it up for easier digging.

In some cases, you need to blast stumps before digging them out.

This operation should only be done by qualified blasters—the purpose is to split the stump, not blow it out of the ground!

You may "doze" over and pile small trees and brush without cutting them. Burning debris piles may improve the appearance of your property, but you may wish to avoid the liability of using fire and the extra difficulty this practice entails. Scattering the debris below the fill slope is an acceptable alternative, provided it does not enter streams.

**Excavation to grade.** Most woodland roads are built by excavating a road surface out of a hillside (construction requiring fill material is treated later in this publication). The machine used most often for hillside excavation is the crawler tractor (bulldozer).

The road design and field layout marks the top of the cut slope, indicates the steepness of the cut slope, and provides the vertical distance down to the final grade. This basic information allows the machine to start at the top of the cut slope, and excavate and sidecast material until the desired road width is obtained (see figure 1).

In some cases, you may need to build a bulldozer ramp to the top of the cut slope from the pioneer road. The bulldozer then makes successive passes until road width and grade are achieved.

Cut slope steepness (3/4:1 or 1:1) is critical (see EC 1137). If the design calls for a 1:1 cut slope, and instead you construct a 3/4:1 (or steeper) cut slope, you will achieve the road width before you excavate to the desired grade (see figure 2).

You will then need further excavation to cut the road down to grade. This will produce extra road width; depending on soil conditions, the oversteepened cut slope may fail.

On some road segments, the cut slope error may be acceptable, if you can adjust the final road grade and alignment. However, once you excavate the cut slope, there is no way to put the material back on the slope and correct the problem.

The road design will indicate whether the road is to be built with balanced road sections, full-bench sections, or partial fill sections (sidecast materials forming part of the road surface). During construction, the initial handling of excavated material and its final deposit are crucial.

A common bulldozer procedure is to sidecast the excavated material very close to where it is excavated. You can form part of the road surface with this material or you may deposit it along the roadway—provided it will not cause a landslide or wash into streams.

Depending on the type of blade used, bulldozers can push or "drift" (contain the material in front of the blade) excavated material up to 300 feet along the road section to deposit it in stable places. When the extra excavation is more than a bulldozer can sidecast or drift, you will need additional equipment (scrapers or dump trucks) to haul material to a waste disposal area.

**Constructing fills.** Road fill sections typically are used to cross stream drainages, flat areas, and swamps and are used as waste areas for extra excavation. A fill is not simply an area where you dump material; it must support traffic, so you must construct it of adequate materials and compact it to a specific level to develop strength.

It is important to estimate the expected width of the fill area and prepare the contact surface so the fill materials adhere to the original ground surface. The width of fills on flat ground is, at a minimum, three times the road surface width (depending on the height of the fill). Fills on gentle slopes may not extend as far on the uphill side as on flat ground, but they will extend further on the lower side (see figure 3).

Construct fills by spreading and compacting layers (lifts) of material from 12 to 18 inches deep before compaction. The amount of compaction depends on the type of equipment used, the soil type and

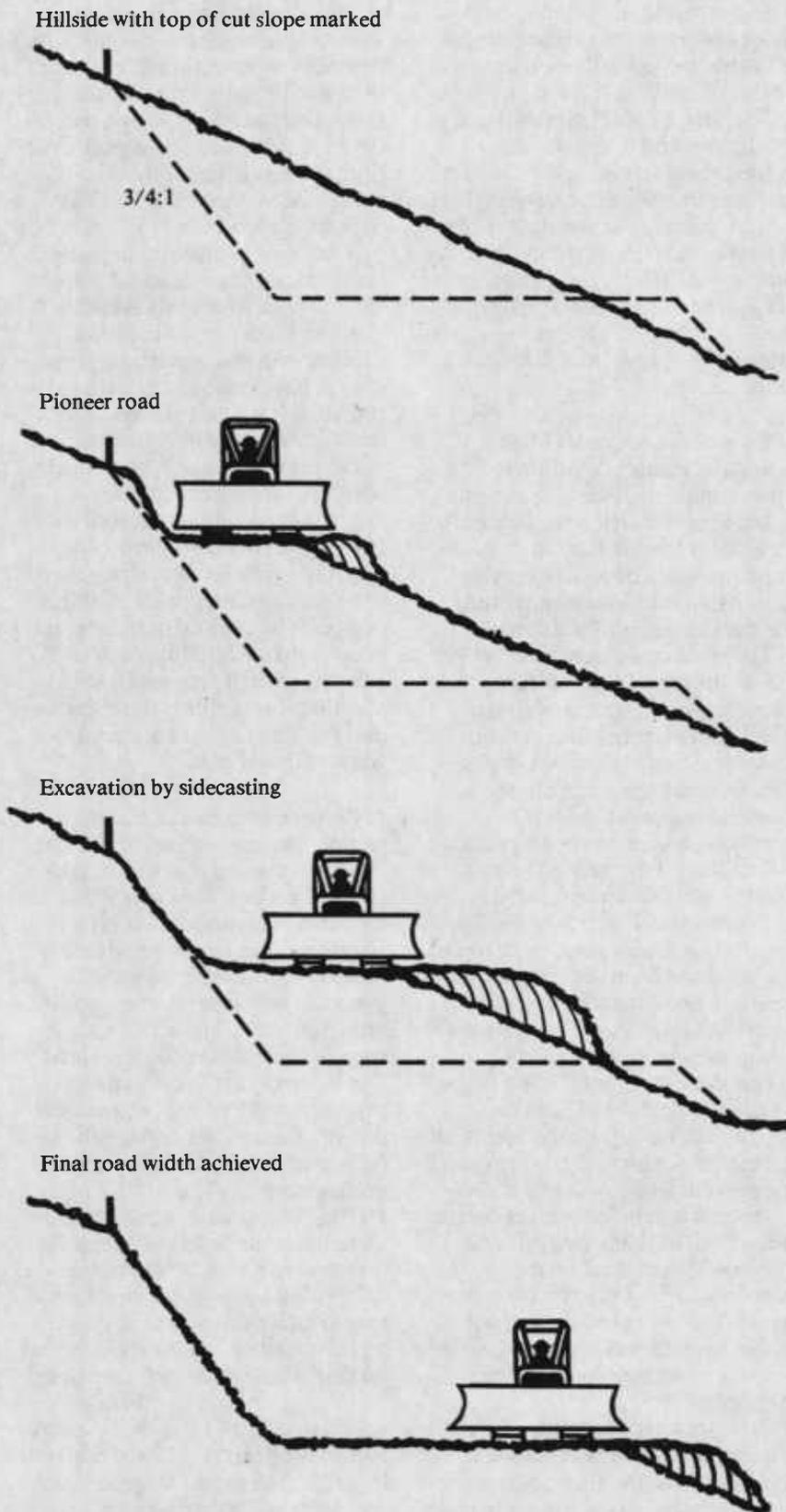


Figure 1.—Road excavation with a bulldozer.

moisture, and the number of machine passes. Compact each lift as much as financial considerations allow. (A bulldozer is not a good machine for compacting large fills; other machines are available and are more effective.)

Spread and compact the widest lift and bring up each lift at the fillslope of  $1\frac{1}{2}:1$  or  $2:1$ , as designed (see figure 4). Remove rocks and debris from fill materials as you add the lifts.

Fills across drainages are especially critical because they may act as dams during severe storms. It is a poor construction practice to build up fills by end dumping instead of layering and compacting (see figure 5). When the depth of the fill is more than 10 feet at centerline, build the earthwork structure carefully to support traffic loads. Also, avoid using machines directly in the stream channel upstream and downstream from the fill itself.

**Rock excavation.** On most woodland roads, it is best to avoid constructing the road through rock outcrops. Use alternate locations nearby for the road section or reroute the entire road to avoid costly rock excavation.

If short sections of rock are unavoidable, you can use special equipment to dig it. Two rock-digging devices are the hardened corner bits on dozer blades and rock rippers that are attached to the rear of a crawler tractor.

You'll need a larger crawler tractor than one used only for earth excavation. Also, for the rock ripper to be most effective, you must build the pioneer road above the rock so you can dig from above.

Corner bits on blades work best for digging at the rock from the side (see figure 6). Some rock outcrops may consist of large boulders that you can simply dig out and remove from the roadway.

When rock is hard to dig, blasting is necessary. Not only is this technique very costly, but it must be done by qualified blasters.

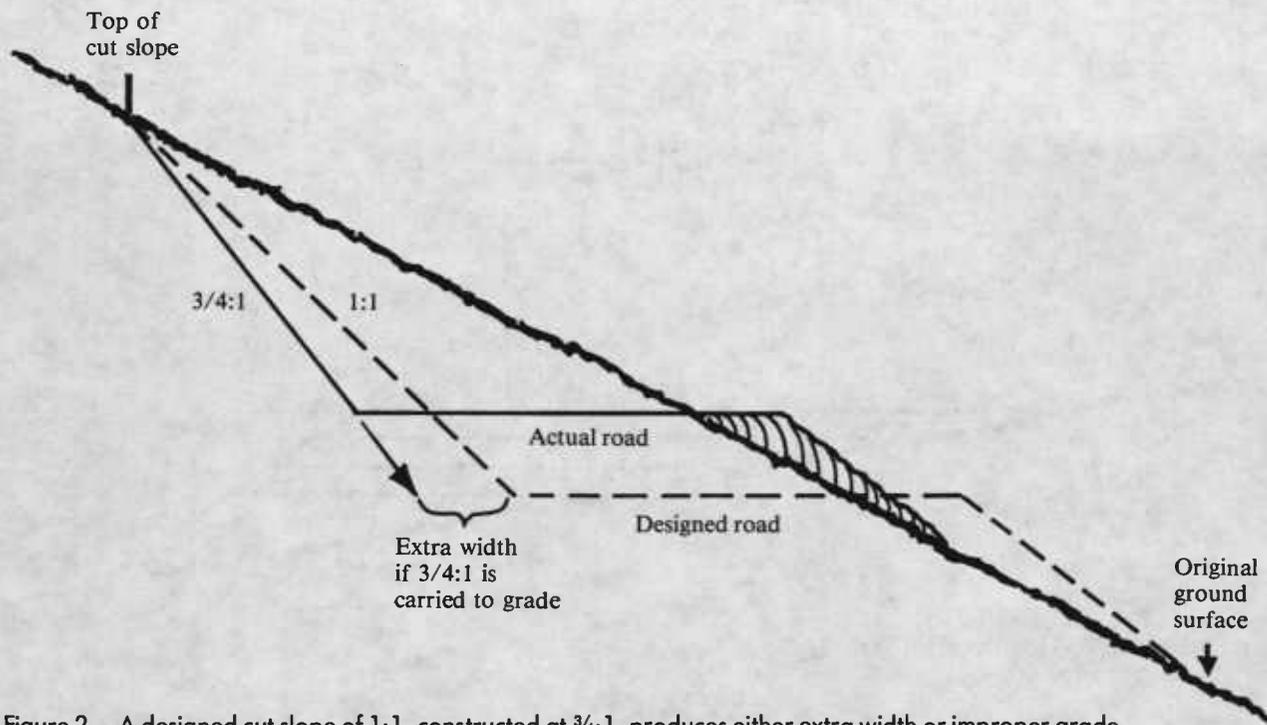


Figure 2.—A designed cut slope of 1:1, constructed at 3/4:1, produces either extra width or improper grade.

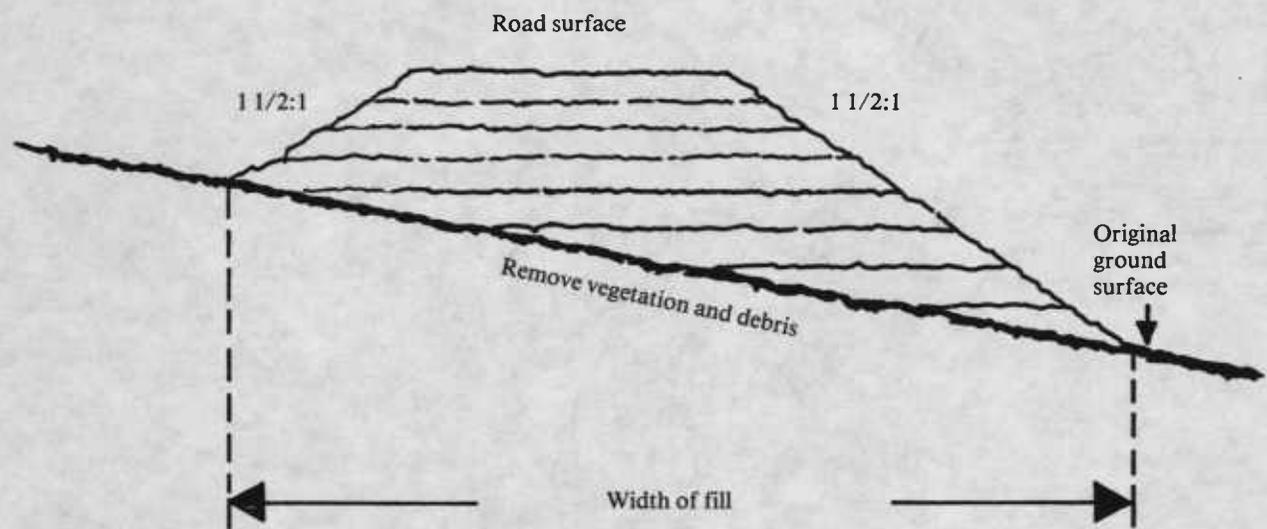


Figure 3.—Fill on a gentle slope.

There are various drilling patterns, powder selections, and fuse timing schemes that will produce the rock shattering needed to excavate the roadway. There are also special legal requirements for blasting activities.

Rock blasting can benefit woodland owners if the rock type and location provides surfacing materials for roads. Professional

advice may also help you determine if developing a commercial rock pit is a feasible alternative.

**Subgrade compaction.** Once you excavate the road to the designed subgrade, you need to compact it. Compaction will not only save on

the amount of rock you need for surfacing, but if the road is to remain a dirt road, compaction will make it more stable, less erosive, and better for traffic. Coordinate compaction activities with road-building activities. If the road is scheduled for immediate surfacing, compact the subgrade after excavation. If the road is to remain

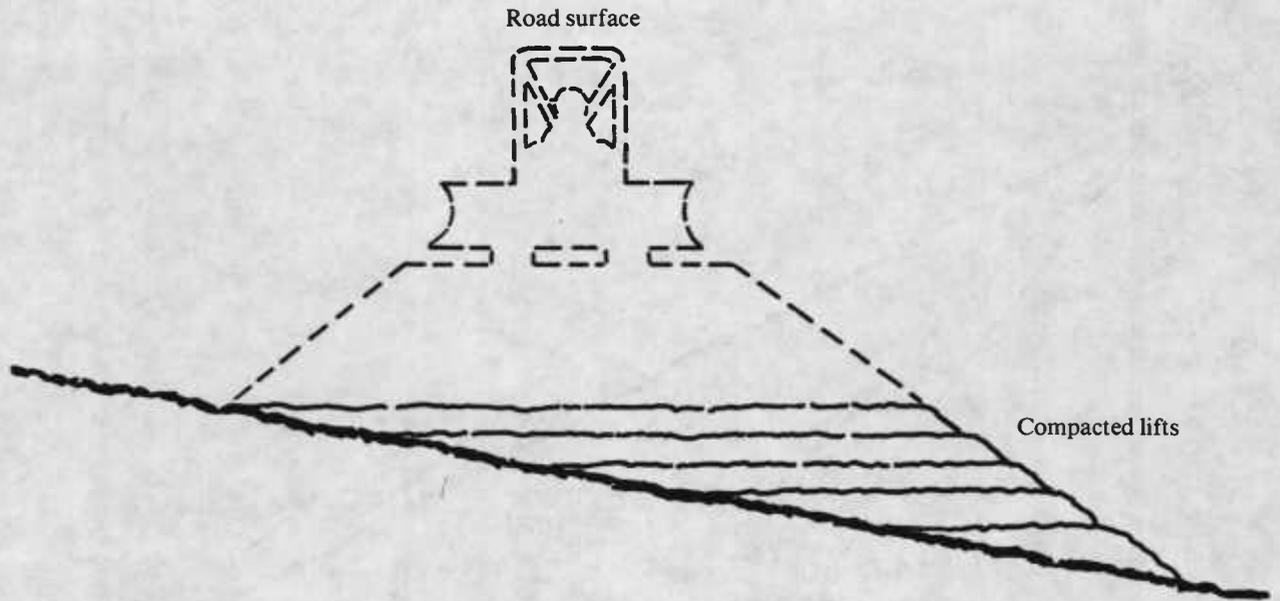


Figure 4.—Building fills by compacting lifts.

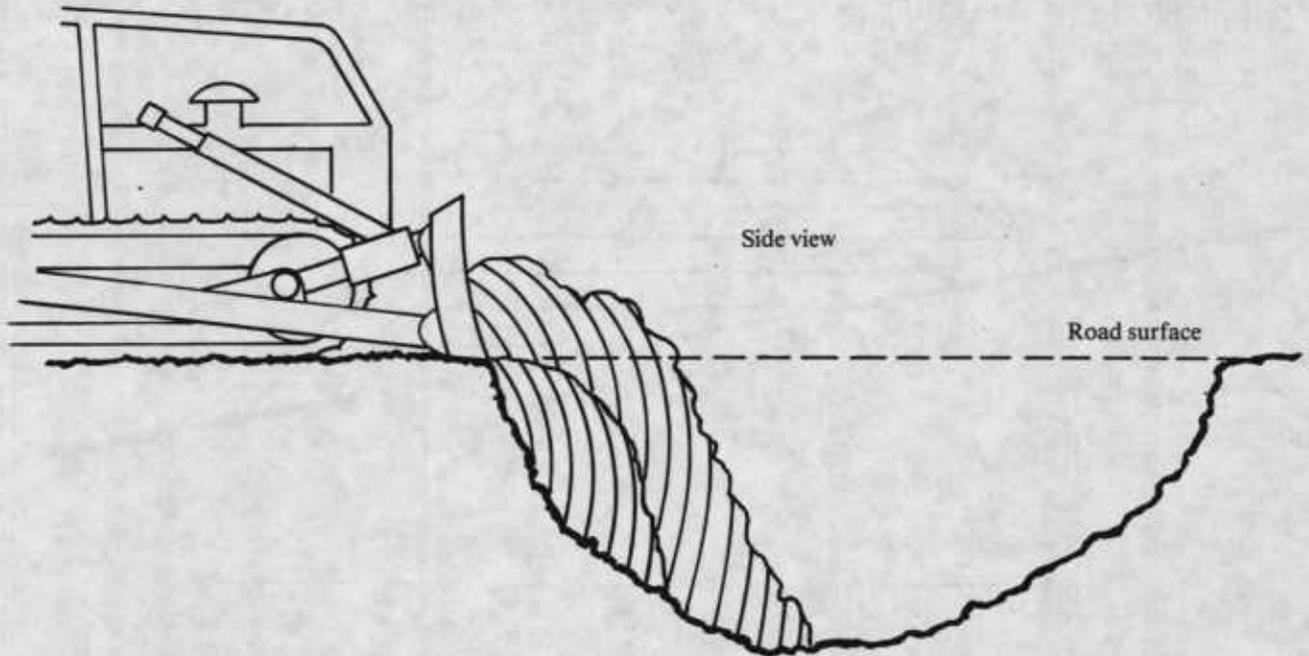


Figure 5.—End dumping is a poor practice for constructing fills needing strength.

unsurfaced through the winter, you can either compact the subgrade after excavation or just before surfacing.

Crawler tractors tow several types of compaction devices (some may be self-powered). Their effectiveness depends on the soil type and the

number of passes over the subgrade. Soil moisture content also is important.

Soil will compact most efficiently at the correct range of soil moisture. If the soil is too wet or too dry, it will compact very little or not at all.

You can identify the correct range by turning the soil. It should appear darker in color than the surface, and there should be no water visible in the soil and no puddles nearby. Turning the soil should not produce any dust (indicating the soil is too dry).

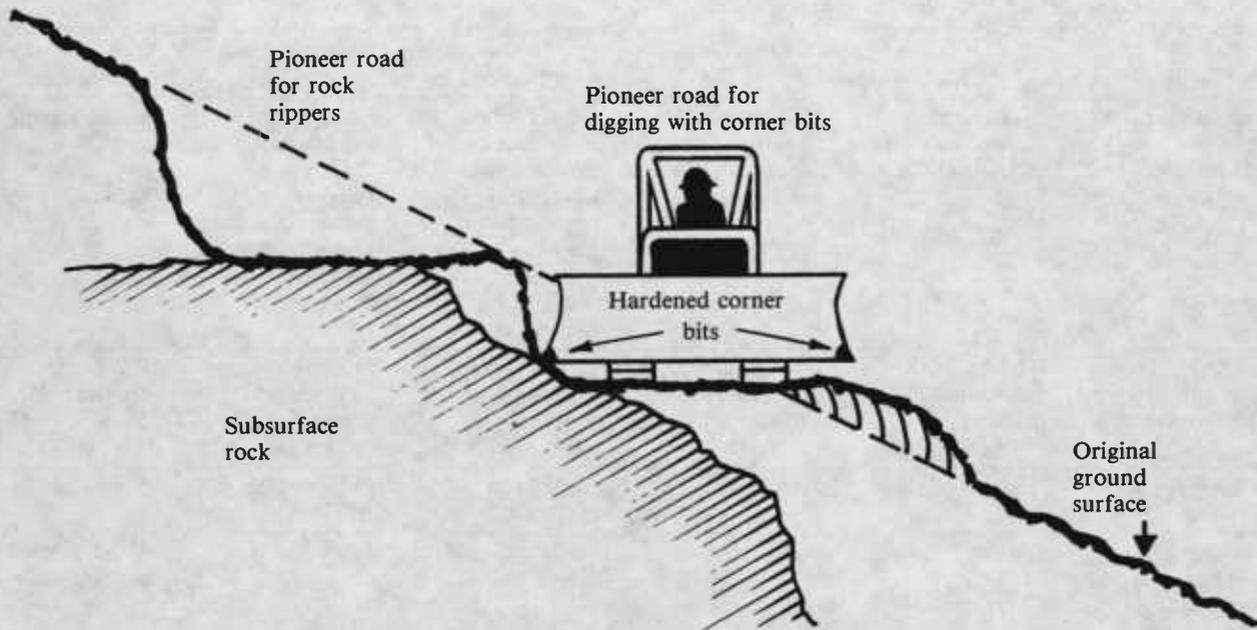


Figure 6.—For effective rock ripper use, pioneer roads need to be above rock—the corner bits dig at the rock from the side.

Here are four compaction devices you can use:

- *Vibratory roller.* For sand, silty sands, silty gravels, and granular materials.
- *Steel tandem roller.* For sandy silts and most granular material with a clay binder. (Compactible clay particles help hold granular materials together.)
- *Sheep's foot roller.* For clays, silty clays, and gravel with a clay binder.
- *Pneumatic tires.* For all soil types.

Some roadbuilders mistakenly believe that running a bulldozer back and forth over a road surface compacts the subgrade effectively. The compaction bulldozers provide is achieved so inefficiently that it is often not worth the effort.

If you surface a road, start at the back, and the gravel trucks will provide some compaction by tracking over the entire subgrade surface rather than in the same tracks. Also, you may prefer to surface the subgrade after it has overwintered and settled (be sure to

provide for drainage before winter). This process will compact the subgrade somewhat, but not as much as a planned effort with compaction devices.

### Installing and constructing drainage structures

EC 1137 contains detailed guidelines on how to plan and install drainage features on woodland roads. You typically install them as needed to cross stream drainages, although you can use temporary crossings.

You can install cross-drains, such as culverts or rolling dips, as soon as you construct the ditch and mold the road surface with a grader. Most roadbuilders prefer to install drainage features after the subgrade is nearly complete.

If you expect road construction to extend beyond the first fall rains, make sure the drainage features are functioning before the rains occur.

Compared to the large effort required during excavation of the road subgrade, the amount of effort required to install drainage features may *seem* less important.

Yet, if you construct or install drainage features improperly, complete road sections may fail. Controlling subsurface water and rainfall is crucial for woodland roads because of the potential for erosion problems and landslides.

### Machines for road construction

The type of machinery you can use for building woodland roads varies significantly, depending on the scale and difficulty of the road project. Selecting the type of equipment to use is a decision balancing machine efficiency against operating cost. Table 1 lists machines you can use for road construction and some operating characteristics for each.

The most common roadbuilding machine is the *bulldozer*. Bulldozers are manufactured in many sizes to allow for a match between job requirements and machine capabilities.

Their basic materials-handling technique is to cut and push material into place.

Optional attachments, such as different blades, can improve their

Table 1.—Road construction equipment characteristics

Criteria	Bulldozer	Front-end loader	Hydraulic backhoe	Dump trucks or scrapers	Farm tractors
Excavation mode (level of control of excavated materials)	Digs and pushes; adequate control (depends on blade type)	Minor digging of soft material; lifts and carries; good control	Digs, swings, and deposits; excellent control; can avoid mixing materials	Scrapers can load themselves: "top down" subgrade excavation; used for long-distance material movement; excellent control	Minor digging and carrying; good control because it handles small quantities
Operating distance for materials movement	300 feet; pushing downhill preferred	300 feet on good traction surfaces	75 feet (limited to swing distance)	No limit except by economics; trucks must be loaded	100 feet (approximately)
Suitability for fill construction	Adequate	Good	Limited to smaller fills	Good for larger fills	Not suitable
Clearing and grubbing (capacity to handle logs and debris)	Good	Adequate	Excellent	Not suitable	Handles small material only
Ability to install drainage features	Adequate	Digging limited to soft materials	Excellent	Not suitable	Adequate for small tasks only
Operating cost per hour	Moderate, depends on machine size	Relatively low	Moderate to high, but productivity excellent	Very high	Low
Special limitations or advantages	Widely available; can match size to job; can do all required with good operator	Cannot dig hard material; may be traction limited	Good for roads on steep hillsides; can do all required except spread rock for rock surfacing	Limited to moving material long distances; can haul rock, riprap, etc.	Very dependent on site conditions and operator skill

effectiveness. For example, you can use a U-blade for pushing earth, and an angle blade with hardened corner bits to dig rock. Rock rippers, stump splitters, logging winches, and other rear-mounted attachments make bulldozers even more versatile.

In the hands of a good operator, a bulldozer can do everything on a woodland road from excavation, to final grading and drainage feature installation.

You can use *front-end loaders* for road construction if no heavy digging of hard materials is

involved. Their basic technique for materials handling is lifting and carrying.

Front-end loaders may be tracked or wheeled vehicles; wheeled loaders are faster than tracked loaders, but the tracked vehicles dig more effectively. Some may already be available to woodland owners as log loaders; you can refit them with a bucket for excavation. A variety of bucket types expands the machine's usefulness.

The *hydraulic backhoe* is a relatively new technology used in forest construction roads. This newness may make its operating costs somewhat higher than older, secondhand equipment.

Recent improvements in machine design have given the hydraulic backhoe ease and speed in materials handling. It operates by digging, swinging, and depositing material with good control.

You can use the machine efficiently with a dump truck to end-haul material (digging and hauling material away as opposed to digging and sidecasting the material). It also works well on roads that cross steep hillsides by minimizing the amount of excavated material and effectively controlling the placement of this material. (You have less

control when pushing material with a bulldozer.)

Their productive capacity (stations of road constructed per day) is high. Furthermore, with the exception of spreading rock during surfacing, these machines can do the entire road construction job.

When you move large amounts of material long distances, you will need *trucks or scrapers* in addition to a machine for digging material from the roadway.

You must load trucks with a front-end loader or backhoe. Scrapers may be either self-powered or towed behind a crawler tractor. They load themselves by scraping the material they carry from the top of the subgrade. Arrange conditions so "top down" excavation can occur—scrapers must be on top of material to excavate, unlike machines that excavate from the side.

Trucks and scrapers carry material from one place and deposit it in another. They are very expensive and usually are limited to road sections that must be end-hauled or to the construction of large fills.

You can build some woodland roads with a *farm tractor* equipped with a bucket or a blade, or both. The scale of the project partially determines whether a farm tractor can do an adequate job. Constructing a short road in an area where you can dig the soil easily and where you need no logging, clearing, or grubbing activity, is a job well-suited to a farm tractor.

The effectiveness of the machine usually depends on the skills of the operator. A skilled operator can produce roadbuilding results that are amazing, considering the tractor's limitations.

There is a time consideration involved in using a farm tractor—if the road construction activity takes several months or years, you may lose some marketing and management options during that time. However, once you construct a road, the farm tractor can do a good job of maintenance.

Table 1 provides useful information for selecting road construction

machines. If you are considering equipment rental or leasing options, you may wish to review it. Depending on the scale of the roadbuilding project, you may need combinations of machines to accomplish the job efficiently.

## Special problems during road construction

You may not discover problems with the road project until after you build the pioneer road or begin subgrade excavation. A few of these problems are frequent enough to anticipate—you can plan some possible solutions for these.

**Springs, wet spots, and pockets of unsuitable material.** Subgrade excavation can produce unforeseen problems in the form of springs, wet spots, and pockets of unusable material. For springs and wet spots that are not expected to support the road or carry traffic loads, the easiest solution is to provide adequate drainage. More culverts or even perforated pipes placed in the wet areas can collect water and direct it to a ditch where you can control it.

If springs, wet spots, or unsuitable materials occur in areas where it is impossible to change the road location, and if these areas must support loads as well, you may need to remove the material.

Dig springs and wet spots out of the roadway, install subsurface drain pipes, and replace wet or unsuitable soil (certain clay-type pockets or dark organic soil) with good material.

Use woven and nonwoven fabrics to help provide strength to areas that you cannot dig out completely. Although you may need professional assistance to use these fabrics to their best advantage, you should be aware of their possible use.

Another common roadbuilding problem is the small cut slope failures that often occur in association with springs, wet spots, and poor quality (low-strength)

material. A first approach to the problem is to make the cut slope less steep—closer to the "angle of repose" that the soil will hold. Where water is a contributing factor, subsurface drainage may help solve the problem.

Another solution is a rock buttress. Figure 7 shows a typical rock buttress used to stabilize cut slopes. If a source of large rock is available nearby, you can readily construct a buttress with a backhoe or front-end loader.

**Temporary stream crossings.** When road construction involves complicated stream crossings such as bridges, large culverts, and large fills, you may need a temporary crossing to get beyond the streams or drainages to excavate the rest of the road. Discuss temporary crossings with a forest practices forester before starting the road job (as part of the notification process).

Temporary crossings will work only during periods of low streamflow. On solid stream bottoms, a ford may be an acceptable temporary crossing. In other cases, you can place several cull logs in the stream channel to form a base that the water can flow through.

Cover the logs with gravel to form a travel surface. If gravel is not available, take care to keep soil out of the stream when you remove the temporary crossing.

Do not allow temporary crossings to produce dams or block waterflows. Remove them by late summer so fall rains do not wash them out.

**Encountering rock.** As excavation proceeds, there is always the possibility of encountering subsurface rock. Once you expose the amount and type of rock, you need to decide whether to dig it out or shift the road location.

You can dig weathered rock with a bulldozer equipped with corner bits or rock rippers. The other alternative is to shift the road location outward and downward to avoid encountering so much rock.

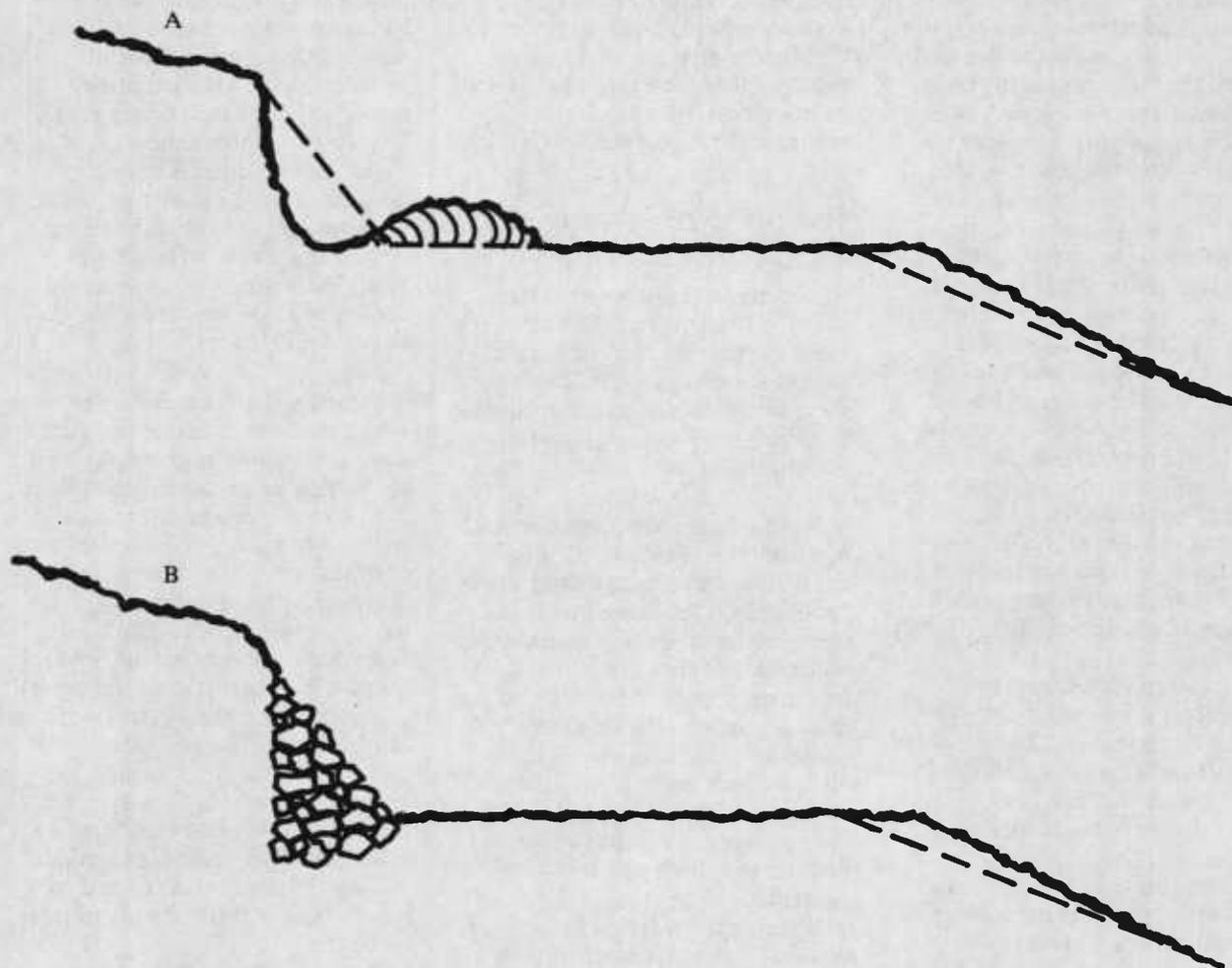


Figure 7.—(A) Cut slope failure and (B) a small rock buttress.

If the rock is on a hillside, revising the road location probably will not have an adverse impact on the road grade and alignment. However, if the rock is in a drainage, shifting the location may create problems with the alignment and grade of the curve. Digging or blasting may then become the preferred action.

**Weather problems.** Even with a carefully prepared road construction schedule, unexpected storms and early fall rains can cause problems. If you anticipate completion problems, it's best to get the road to the point where, if necessary, you can leave it over winter.

Cutoff dates vary according to elevation and local conditions. However, by October 15, fall rains are likely to begin in low elevations in western Oregon and halt further construction activity. Remove all temporary crossings, and make sure drainage features (ditches, culverts, and cross-drains) are functioning by this date.

Take care that erosion features are in place before the first rains. Check that culverts are functioning and use rock outfall or culvert half-rounds to protect the fills below cross-drains. In addition, partially constructed roads may need special erosion-prevention features, such as frequent water

bars and grass seed on exposed soil (see EC 885).

Not only is this type of planning required to avoid forest practices violations, but it will help prudent landowners protect their investment in forest roads.

### Finishing touches

Once the road is excavated (or filled) to grade, there are a number of finishing details to consider. The final surface grading—to make sure ditches and road surfaces are smooth and functional—is usually done with a road grader. However, good bulldozer operators can

“shape up” short stretches of roads. (Don't forget to build the turnouts needed for vehicle passage on single lane roads.)

If you plan to surface the road, review the procedures listed in EC 859. Consider compacting the entire road subgrade before rocking, or, as a minimal measure, use the compactive energy of gravel trucks during surfacing.

Consider traffic control for your new road. Gates, barriers, or other simple devices such as logs or trenches can help eliminate unwanted traffic. You may need cattle guards or fences in some areas.

A well-designed and constructed woodland road is a valuable asset to the property. And, while roads are expensive, much of the success in building woodland roads depends on the knowledge and attention to detail that you bring to a road project.

## For further reading

### OSU Extension publications

In July 1992 the OSU Extension Service publications warehouse was destroyed by fire. We are replacing our supplies. The publications listed below may be available in the office of the OSU Extension Service that serves your county. Check with that office for current prices. You also may call Agricultural Communications at Oregon State University, (503) 737-2513, to learn the availability and current price of the publications.

Adams, Paul W., *Maintaining Woodland Roads*, Oregon State University Extension Service Circular 1139 (Corvallis, revised 1991). \$1.00

Adams, Paul W., *Soil Compaction on Woodland Properties*, Oregon State University Extension Service Circular 1109 (Corvallis, revised 1991). 75¢

Berglund, Erwin R., and Marvin Rowley, *Rocking Woodland Roads*, Oregon State University Extension Service Circular 859 (Corvallis, 1975). 25¢

Berglund, Erwin R., *Seeding to Control Erosion Along Forest Roads*, Oregon State University Extension Service Circular 885 (Corvallis, reprinted 1978). 75¢

Garland, John J., *Designing Woodland Roads*, Oregon State University Extension Service Circular 1137 (Corvallis, reprinted 1991). \$1.75

Garland, John J., *Planning Woodland Roads*, Oregon State University Extension Service Circular 1118 (Corvallis, reprinted 1991). 50¢

Sidle, Roy C., *Impacts of Forest Practices on Surface Erosion*, Pacific Northwest Extension publication PNW 195 (Corvallis, 1980). 50¢

Sidle, Roy C., *Slope Stability on Forest Land*, Pacific Northwest Extension publication PNW 209 (Corvallis, 1980). 75¢

### Other publications

*Field Guide to the Oregon Forest Practice Rules*, Oregon State Department of Forestry (Salem, issued annually).



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*The Woodland Workbook* is a collection of publications prepared by the Oregon State University Extension Service specifically for owners and managers of private, nonindustrial woodlands. *The Workbook* is organized into 11 sections, containing information of long-range and day-to-day value for anyone interested in wise management, conservation, and use of woodland properties. It's available in a three-ring binder with tabbed dividers for each section.

For information about how to order, and for a current list of titles and prices, inquire at the office of the OSU Extension Service that serves your county.

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