EB 1316

A Primer for Timber Harvesting

Washington State University Extension

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Introduction

Decisions by private forest landowners in Washington about timber harvesting alternatives are very important. The timber harvesting system landowners select directly affects their financial return, future site productivity, potential damages to the site or remaining trees, soil erosion, and other factors. Landowners need useful information to plan and conduct timber harvests.

A timber sale entails a complicated set of activities in the management of forestlands for the nonindustrial private forest (NIPF) landowner. Many landowners spend too little time researching markets, interviewing logging operators, paying attention to forest practice laws, and ensuring adequate attention to post-sale concerns. A timber sale embraces more than the single event of harvesting trees; it involves the integration of landowner goals, silvicultural needs, specific site requirements, and the long-term productivity of the site.

Planning

Forest Plans

Timber sales can influence how forests grow. Along with other activities, timber sales determine the long-term management of the forest. To ensure that all activities focus on a common set of goals and objectives, we urge forest landowners to develop a written *forest management plan*. A forest management plan is a detailed document outlining long- and short-term goals and objectives. It includes details about how to move from current forest conditions to a desired future state.

A *forest activity plan* details exactly how to accomplish short-term goals on your property. It includes exact management prescriptions, expected outcomes, and dates when activities will be accomplished. Forest landowners should have a forest management plan written and implemented before undertaking any timber sale on their property.

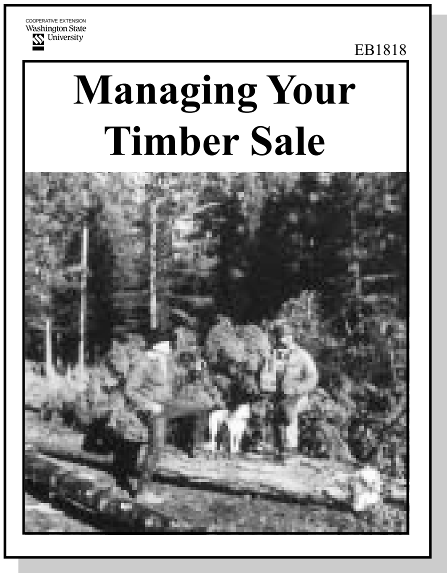
Landowners who want to manage a variety of resources, including timber may wish to develop a *Forest Stewardship Plan* for their property. Forest Stewardship Plans provide an organized and integrated approach to managing for timber, fish, wildlife, soil and water resources, and aesthetics and recreation.

Developing a plan well in advance of potential timber harvesting can provide a clear guide that supports the landowner's long-term goals. A written stewardship plan or forest management plan is required to apply for forestry property tax classification, to join forestry cost sharing programs, or to receive recognition as a Certified Tree Farm® or Stewardship Forest.

Many landowners hire a consultant to prepare their plan. Others participate in *Coached Forest Stewardship Planning Workshops*, where they develop their own plan with instruction from natural resource professionals. Planning assistance also may be available from Department of Natural Resources (DNR) or the USDA-Natural Resources Conservation Service (NRCS) foresters in some areas.

Planning should *always* precede harvesting. Harvest planning involves, at the minimum, collecting information on timber volumes, stem counts, and prices to obtain a suitable logging contract. A harvest plan should specify forest management objectives and indicate how logging should be done to obtain these objectives. Refer to *Managing Your Timber Sale*, WSU EB1818, Figure 1.

Figure 1— *Managing Your Timber Sale*, EB1818, WSU Extension.



Establish management objectives in order of priority. Clearly explain objectives and priorities and make sure your logger understands them.

One common objective is to realize monetary return. Other objectives:

- Improve timber stand conditions for future growth.
- Enhance the wildlife habitat in an area.
- Remove mature timber, while protecting younger trees.
- Enhance recreational values.
- Remove dead and dying material.
- Make a clearing for a home site.

A professional forester or forest engineer can help identify and evaluate these objectives and plan alternative means of reaching them.

Once landowners decide to harvest timber, they must also decide whether to harvest the timber themselves or to hire a logger. There are both advantages and disadvantages to landowners conducting their own logging. Some of the advantages of self-logging:

- Possibly lower logging costs, bringing extra income to the landowner.
- Better control of the logging operation with respect to when, where and how it is carried out.
- Smaller scale harvesting or selection of smaller trees that might not interest a commercial logger.
- Self-satisfaction to the landowner.
- Inclusion of some operations otherwise not economically feasible, such as pruning crop trees during a thinning operation.
- Increased knowledge of the timber market leading to better decisions in future management of the timber resource.

Disadvantages of self-logging include:

- Physically demanding and often dangerous work. Logging is one of the top ten most dangerous jobs in the U.S.
- Costly investments in either the purchase of logging equipment or the modification of farm equipment.
- Lack of necessary skills, such as how to fell trees or how to rig and operate a cable system.
- Decreased/diminished value due to inexperienced handling of the logs; e.g., poor felling and bucking, or, losses due to insect attack and stain when felled trees are not removed in a timely manner.
- Loss of value because of a poor understanding of the log market; viz., producing the wrong product at the wrong time for the wrong buyer.
- Lack of time or desire by the landowner to do the logging job.

Professional Assistance

Forestry and forest engineering assistance is available to landowners from a number of sources. The forest landowner is strongly encouraged to seek and use professional help. Timber harvesting can be a complex undertaking where the financial and environmental results are long lasting. Sources of professional help are identified and discussed in the following section.

Public Agencies

Public agency foresters can give you overall management advice for your property, including general information about timber sales, how to find consulting foresters and loggers in your area, and information about reforestation and other silvicultural practices.

WSU—Extension Forestry

Washington State University Cooperative Extension has county offices across the state. Personnel specializing in forestry and forest management provide educational assistance to private forest landowners through workshops, demonstrations, field tours, written materials, video demonstrations, and one-on-one visits. Washington State University Extension Forestry in Washington is the educational branch of forestry assistance, and is the USDA and state agency providing this publication. For additional information on timber sale preparations, obtain *Managing Your Timber Sale*, WSU EB1818. In other states, similar publications are available from Cooperative Extension at your land grant University.

DNR Forest Stewardship Assistance

The nonregulatory Washington Forest Stewardship Program is designed specifically to advise and assist forest landowners. The Washington Department of Natural Resources (DNR) has stewardship foresters and a wildlife biologist available to advise interested landowners about management activities that best achieve their objectives. They customize advice to meet the needs of each individual landowner. Landowners can request a site visit by contacting the DNR Region Office serving the area where their property is located (toll-free number 1-800-527-3305). Out-of-state landowners should contact their state forester for similar assistance.

DNR Forest Practices Assistance

In Washington, the state's Forest Practices Act and Forest Practices Rules regulate timber harvesting and related activities such as road construction, chemical application, and reforestation on private lands. The Act and subsequent rules protect water, fish, wildlife, and capital improvements of the state and its political subdivisions, while maintaining a viable forest products industry. The DNR forest practice foresters provide field administration and assistance. Forest practices office staff in each of the seven DNR Region offices are available to answer your questions, to help you understand current regulations, and to assist you in obtaining a permit. Copies of the Forest Practices Act and Rules are available from any DNR Region office. *Forest Practices Illustrated*, a popularized guide to forest rules and regulations, is available from the DNR. See Figure 2.

USDA-NRCS Technical Forest Assistance

Technical assistance from the USDA Natural Resources Conservation Service (NRCS) (formerly the Soil Conservation Service) is also available. NRCS conservation planning assistance to forest landowners is available in most areas. The NRCS also administers numerous USDA cost-share programs for conservation purposes.

Private Assistance

Private Consulting Foresters

Publicly employed foresters do not estimate the volume and value of timber, lay out timber sales, supervise logging, or market timber for private landowners. Private consulting foresters provide these services. A consultant forester is not a log-purchasing agent. A landowner must understand the difference between the services provided by a private consulting forester and a log-purchasing agent. The private consulting forester is the advocate agent of the landowner, dedicated to ensuring the best interests of the landowner. The log-purchasing agent is a representative

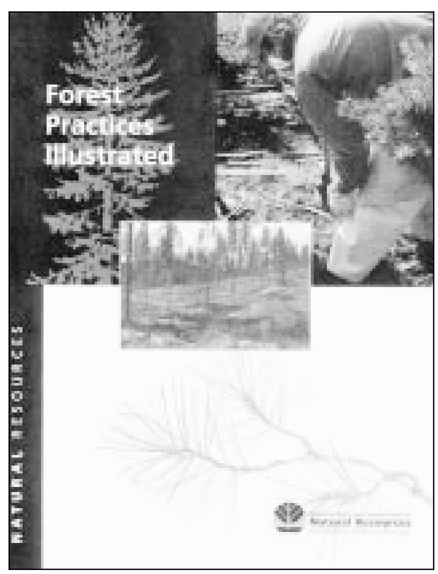


Figure 2—*Forest Practices Illustrated*. Washington State Department of Natural Resources publication

of a mill dealing in the sale and purchase of timber commodities, and works for the log purchaser, not the landowner. This is not to say that mills are untrustworthy, but the landowner must be aware of the role that the log-purchasing agent provides under this situation. Lists of consulting foresters and forestry consulting companies are maintained by WSU Extension on the Internet (http://ext.nrs.wsu.edu). A published version (EB1303, Consulting Foresters Directory for Washington Landowners) is available from WSU Extension Bulletins Office. The Society of American Foresters (SAF) maintains a list of certified foresters, which can be obtained through the national office of the SAF. The Association of Consulting Foresters (ACF) specializes in consulting foresters that have met minimum educational and experience guidelines for membership. ACF can be reached at the following number (703) 548-099.

We strongly recommend the services of a consultant forester when initiating timber harvesting planning and layout.

Log Mills, Timber Brokers, and Log Brokers

A timber or log broker is an individual or business that buys timber for the purpose of selling logs to other log brokers or to manufacturing facilities. These businesses generally do not manufacture the logs they purchase. Many times, these businesses have a log yard or storage facility to sort logs of various tree species and sizes. Yards can ship sorted loads to buyers at higher prices. Occasionally, log brokers will ship logs directly from the logging site to the next buyer of the logs. In some cases, the log or timber broker will buy standing timber, hire a logging operator to harvest the timber, then pay the landowner some amount specified in a contract. The log or timber broker rarely provides professional forestry assistance to the forest landowner.

Logging Operators (Loggers)

The logging operator (logger) is the backbone of the forest industry. These individuals and businesses often complete road construction, timber harvest, log manufacture, delimbing, bucking, erosion control and various other duties involved in a timber sale. Good operators and poor ones exist in many industries. Unfortunately, poor logging operations are more visible to the general public and overshadow the good logging operations in our region. A logging operator's business focuses on the harvest and manufacture of timber and logs from a forest. While operators offer other services, logging operators, at a minimum, will harvest designated trees, manufacture logs from those trees, load them onto logging trucks, ensure their delivery to specified mills or log buyers, and complete logging site clean-up activities.

As a harvester of timber products, a logging operator can fill two important roles.

- The first role is in a "delivered log sale" in which the forest landowner hires the logging operator to complete the logging operation within the constraints of a contract. The logging operator harvests the timber, manufactures the logs, and delivers the logs to mills as specified in the logging contract with the forest landowner. These logging operators never actually purchase the logs; they simply deliver the logs on behalf of the landowner. The logs are paid for generally on a biweekly basis as the deliveries arrive at the mill facilities.
- In a second situation, the logging operator buys the timber from the forest landowner. The logging operator is still responsible for harvest of the timber and manufacture of the logs, but the logging operator takes possession of the logs as soon as they are loaded onto the logging truck. The logging operator is responsible for marketing the logs to the area's mills and brokers.

The Washington Contract Loggers Association (WCLA) maintains a list of loggers who have completed their Accredited Logger Program. This program includes classroom instruction in ecology, silviculture, safety, first aid, and similar topics. Contact WCLA at (360) 352-5033 or 1-800-422-0074 for more information. Their Internet web site is http://www.loggers.com/.

Important Considerations in Timber Harvesting

Harvesting Limitations

In any timber harvesting operation, important considerations will influence, and in some cases, limit the choice of timber harvesting systems to be used. Two such limits are yarding distances and slope deflection (Figure 3). Other factors include:

Timber size

Timber size, based on tree diameter and height, has a direct effect on the type and size of logging equipment used. Maximum and average log sizes are both important. Log weight can be determined from these estimates. Log weight is a significant variable because it determines the economics and mechanical feasibility of ground skidding and cable yarding equipment. The best size and type of logging equipment can be determined from this information.

Daily production requirements

The production potential of different logging systems can vary widely. If timber must be harvested in a short time period, the daily production method required may be high. If time is not an important factor, lower daily production harvesting systems may be suitable (see Tables 1, 2 and 3.)

Harvesting costs

Logging equipment costs differ. Some systems can operate within a wide range of costs, while others are on the high or low end of the scale. If the logger must conduct extra slash cleanup or remove dead and dying trees, production costs will be higher. "Extras" cost more. A consulting forester can determine what production costs are acceptable and assist the landowner in negotiations with the logger. The financial return from timber harvest is in the difference between what it costs to harvest timber and the price of logs at the mill. "Extras" always reduce the value return to the landowner. The contract should specify time allowed to harvest, extras, and other limits. These contract features affect the return to the landowner and vary dramatically. An example contract is available in *Managing Your Timber Sale*, WSU EB1818.

Silvicultural treatments, or cutting practices

The choice of silvicultural harvest systems, such as patch clearcut, shelterwood, or commercial thinning, will influence the choice of timber harvesting methods. In small timber, it helps to identify stands receiving different treatments accurately. Certain harvest systems are not compatible with some silvicultural prescriptions. For example, thinning by a highlead cable system is impractical.

Topographic limitations

Ground slope is one of the most important limiting factors when logging. Determine the slopes of a harvest area then divide by the number of acres in each slope class. Three common slope classes are

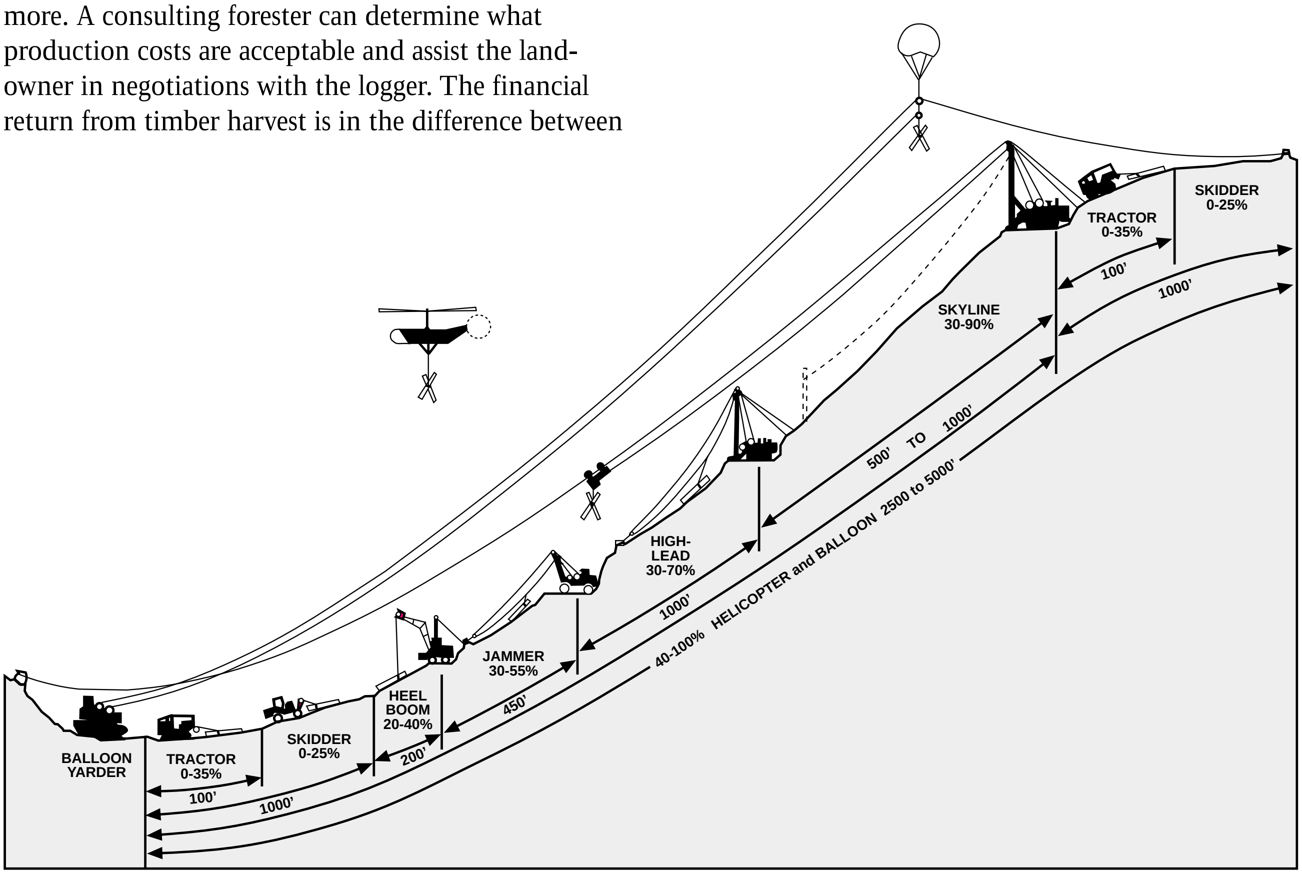


Figure 3 — Optimum yarding distances and slope percentages of each logging system.

0% to 35%, 35% to 70%, and above 70%. Different logging systems may be required to log timber from different slope classes. Other topographic conditions can limit logging feasibility, especially for cable yarding systems. Convex slopes, unevenness of terrain, and long constant slopes can present problems. An experienced forester or forest engineer can help identify these areas. See Figure 3.

Existing roads

Existing road locations and accessibility are related to terrain conditions. Determine the length of road required for logging and its location in advance. If the present road system is not suitable for harvesting operations, roads must be improved or new roads will have to be built. If road construction is to be part of the harvesting operation, specify requirements within the contract.

Spacing between roads and the type and location of landings are major determinants of total harvesting costs. Appropriate road construction standards and proper location on the ground are central factors in determining the immediate income from harvesting and future net economic benefit from the forest. A poorly built and improperly located road system is costly to maintain, removes timberland from production, degrades the environment, and increases future expenses for road maintenance.

Forest Site Disturbance

Stand damage is typically defined as damage to the crown, bole, or roots of a residual tree during harvest. Damage is typically considered a problem when the cambium is exposed or when infection and rot result from the damage. These scars are often called a "catface." See Figure 5. You must define damage based on maximum area of acceptable damage to the tree and the maximum number of trees in the residual stand that can be classed as damaged. Typically, scars down to the cambium with a four square inch area are classed as damage. Most landowners will not accept

Slope Determination

Ground skidding systems work best skidding downhill on moderate (less than 30%) ground slopes. Skidding cycle times are slow when pulling logs uphill. Skidding is best when done straight downhill; less soil disturbance occurs, the logs being skidded do not roll and damage the residual stand, and machine stability is enhanced. The maximum desirable slope percentage will vary depending on the physical properties of the soil, soil depth, and moisture conditions. (See table 1.)

Calculate slope percentage by dividing the vertical rise by the horizontal run and multiplying this figure by 100. (See Figure 4.)

Percent Slope = Rise/Run x 100

Example: 20 feet of rise in 80 feet of horizontal distance

Percent Slope = (20/80)*100 = 25%

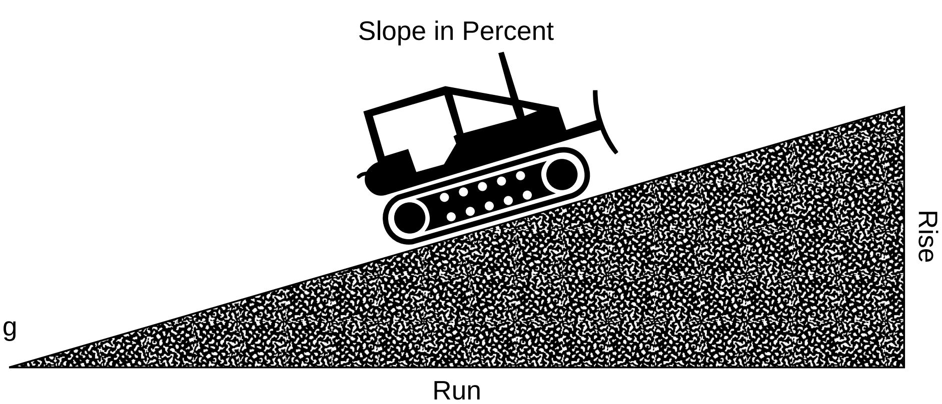


Figure 4 — Measuring slope percentage.

more than 10% damage in the residual stand. Site damage refers to soil-related damage either through compaction, tire rutting, or erosion during harvest. Site occupancy refers to the amount of land area taken by roads and landings during harvest. Stand damage refers to tree-related injuries that occur during harvest. Control for these three important factors during harvest operations.

Minimize all site damage to avoid causing erosion, stream pollution, and reduced productivity on the site. Certain logging systems can be used to minimize site damage, particularly compaction and rutting. Planning of road placement also can limit erosion and compaction problems during harvest.

Specify the acceptable level of site disturbance. Show the logger the areas that are not to be disturbed by logging. Clearly mark these areas by placing ribbon or tags on boundary trees. Instruct loggers to minimize soil disturbance and the damage to residual trees. *We recommend preplanned skid trails. These actually result in very little additional logging cost while greatly minimizing skid trail related damage.*

Site occupancy refers to the area of a harvested tract taken up by roads and landings. In some areas, limits are placed on site occupancy levels. A good limit to consider when harvesting is to have no more than 7% of the tract in roads and landings and less than 10% in skid trails. This limit will vary depending on terrain and the type of logging system used during harvest.

Forest Practices Act

Forest landowners have a major responsibility to protect streams under the State's Forest Practices Act. Determine the classification of any stream course. A DNR forester can determine the stream classes and indicate the corresponding type/level/degree of stream protection required. If you plan to use a cable harvesting system, specify whether the logs must be fully suspended over stream channels or if partial suspension is permissible. See *Forest Practices Illustrated* (Figure 2), available from the DNR.

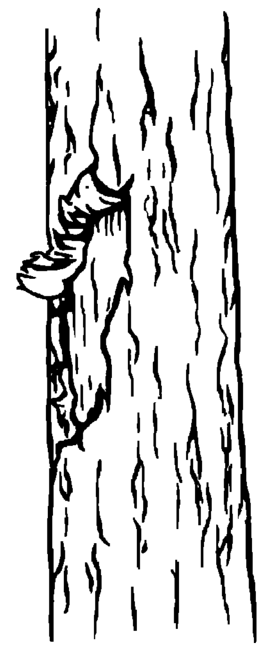


Figure 5 — "Catface." This damage is often the entry court for fungal pathogens. Internal wood rot commonly results.

Table 1. Maximum Slopes for Ground Systems.

Equipment	PSI**	Maximum desirable grades* % Favorable (downhill)	% Adverse (uphill)
Horses	9-15	40	10
Crawler tractors	6-11	35	15-20
Wheeled skidders	10-16	35	0-15
High speed tracked skidders	3-5	30-40	20-30

Source: Adapted from Logging System Guide, USDA FS, R-10.

*Although equipment can operate on steeper slopes, the damage to the site has increased to the point where it is unacceptable.

**The psi (pounds per square inch) listed are based on equipment weight. However, soil disturbance is more closely tied to equipment in motion. On compactable soils, wheeled machines will have the greatest impact. Tractor and wheeled skidding is not desirable on easily compacted soil.

Table 2. Ground-based Yarding Systems.

Factor	System					
	Horses	**Farm tractors**	**Wheeled skidders**	**Crawler tractors**	**High speed tracked skidders**	**Shovel logging**
Timber size capability	Small-medium timber, less than 24 inch DBH.	Small-medium timber less than 24 inches DBH.	All sizes within design range of machine.	All sizes, within design range of machine.	All sizes within design range of machine.	All sizes within design range of machine.
Slope and topographic limitations	Gentle, short downhill pitches to 40%.	Up to 30%, poor for sidehilling, downhill best.	Up to 35%, downhill preferred.	Up to 35%, downhill preferred.	Up to 40%, downhill best.	Downhill on uniform slopes is preferred; moderate uphill slopes.
Production potential	Low	Medium to high	Medium to high	Medium to high	Medium to high	High
Maximum yarding distances (feet)	500 ft.	500 ft.	1000 ft.	700 ft.	2000 ft.	200 ft.
Silvicultural system limitations	None	None, some damage to residuals in thinnings. Machine width may limit tree spacing.	None, some damage to residuals in thinnings. Machine width may limit tree spacing.	None, some damage to residual timber in thinning. Machine width may limit tree spacing.	None, some damage to residuals in thinnings. Machine width may limit tree spacing.	Best applied in clearcut or very heavy partial cut. Some use in thinning.
Road access requirements	Haul roads near skid roads 300 ft. to 500 ft.	Haul roads near skid roads 400-600 ft.	Long distances feasible, but most economical 800-1,500 ft.	Medium distances, road spacing 800 ft.	Medium distances to 3,500 ft.	High truck road density.
Stream protection	Excellent	Can be excellent. Stream crossings need preparation.	Can be excellent. Steam crossings need preparation.	Can be excellent. Steam crossings need preparation.	Can be excellent. Stream crossings need preparation.	Excellent
Forest soil disturbance	Minimal with good practices.	Medium to high disturbance depends on practices, landings 50-75 ft. diameter.	Medium to high disturbance, with grapple machines. Landings 50-75 ft. diameter.	Medium to high disturbance. Depends on practices, landings 50-75 ft. diameter.	Medium to high disturbance with good practices, 50-75 ft. diameter landings.	Minimal
Slash disbursing capability	Low	Yes	Yes	Yes	Yes	Yes
Suitability for firewood harvest	Excellent	Excellent	No	No	No	No
Availability of contractors and equipment	Depends on local area.	Common usage throughout Washington.	Common usage.	Common usage.	Occasional.	Common.
Yarding cost per unit of production	High	High	Low	Moderately low	High	Low
Road development cost per unit of production		High	Low	Moderate	Low	Moderate to high

Table 3. Cable & Aerial Yarding Systems.

Factor	System				
	Jammers	Highlead	Standing skylines	Live skylines	Helicopters
Timber size capability	Small to medium timber.	Medium to large timber.	Medium to large timber, small logs in thinnings.	Small to medium timber; small timber in thinnings	Log weight limit based on helicopter used
Slope and topographic limitations	30%-55% slopes	Limited by deflection, but suited to steep slopes, 30%-70%	Limited by deflection, but suited to steep slopes, 30%-70%	Limited by deflection, well suited to steep slope, 30%-90%	No limits
Production potential	Medium to high	Medium to high	Medium to high	Medium to high	Very high. Weather may limit operability.
Maximum yarding distance (feet)	450 ft.	1000 ft.	4000 ft.	4000 ft.	3-4 miles
Silvicultural system limitations	Clearcuts, partial cuts along roads 100 ft.	Clearcuts	Partial cuts, cuts, thinnings	Clearcuts, partial cuts, thinnings	No limits
Road access requirements	Road spacing: 300-500 ft.	Road spacing: 800 ft. up to 1,500 ft.	500 ft. to 4,000 ft. road spacing	800 ft to 4,000+ ft. road spacing.	Limited only by economics.
Stream protection	Poor to moderate	Poor to moderate	Good	Good	Excellent
Forest soil disturbance	Moderate	Moderate	Minimal to moderate. Some damage to residuals during thinnings or partial cuts.	Minimal to moderate. Some damage to residuals during thinnings or partial cuts.	Minimum 1—1 $^{1}/_{2}$ acre
Slash handling capability	Yes (expensive)	Yes (expensive)	Yes (very expensive)	Yes (expensive)	No
Suitability for firewood harvest	Yes	Yes, with smaller machines can be expensive.	Yes, with smaller machines can be expensive.	Yes, with smaller machines but can be expensive.	No
Availability of contractors and equipment	Common on eastside, few on westside.	In common usage on westside, growing on eastside.	In common usage on westside, growing on eastside.	In common usage on westside, growing on eastside.	Limited (few contractors).
Yarding cost per unit of production	Moderate	Moderately high	High	Moderately high	Extremely high
Road development cost per unit of production	Low	Moderate	Low	Moderate	Very low

Slash Handling Capability

Different harvest systems have different slash handling capabilities. Keep slash concentrations in the forest to acceptable levels. Too much slash poses a fire hazard and can adversely affect regeneration. The DNR can advise the landowner as to proper slash treatment options. Generally, slash is "lopped and scattered" about the forest floor. This option allows recycling of the nutrients held in the slash into the ecosystem. Other options include piling and burning or broadcast burning. The logger should understand the acceptable level of slash cleanup. You may want to include this in the contract.

Availability of Equipment and Contractors

The number of logging contractors using a particular harvesting system often is limited. Some systems, such as highlead or rubber-tired skidder, are very common, while continuous cable systems or cut-to-length harvesters are employed less frequently. Availability of specific equipment also can depend on location within the state. More elaborate or specialized harvesting systems—multi-span skylines or horse loggers—are difficult to locate in certain areas.

Forest Access

The forest road system represents a major investment by the landowner. Well-located, designed, and constructed roads serve the immediate and future purpose of enhancing the value of the forest property. Poorly conceived and implemented roads will be a continuing burden.

Good road location is essential. It is difficult, sometimes impossible, but always expensive to compensate for bad location through remedial design, construction and maintenance. Usually loggers are not proficient in locating roads. If a significant amount of road must be constructed, you, the landowner, should obtain the services of a licensed forest engineer. It is tempting to let the logger build the road without professional guidance and oversight, especially when the ground is flat and presents little construction challenge. However, you may then find too much road has been built, usually to a low standard.

The Logging Process

Felling and Bucking

Felling and bucking are the first steps in preparing a tree for market. They can have a major effect on the rest of the harvesting operation. Proper felling and bucking can maximize the marketable products into which trees are cut; lower harvests' costs, and yield more usable volume.

- Planning

  Planning is an important step in felling and bucking. A walk through the area to be harvested can help evaluate the terrain and timber. Address the following questions:

  What kind of terrain does the timber occupy? Is it steep? Is the ground uneven with ridges and gullies that would break the trees as they are felled? Are stumps and rocks scattered on the ground that would increase tree breakage?

  How do the trees lean? On steep ground trees usually lean downhill. Trees often lean away from the prevailing wind direction. How many defects are present in the stand? Stem and root rot can make trees dangerous and more difficult to fall.

  Do you see many windfalls or areas of blowdown? Blown over, entangled trees can present serious dangers to anyone bucking with chainsaws. If the remaining trees are felled onto the windfalls, expect excessive breakage. Loggers may have to buck and pull wind fallen trees into the desired direction with machinery. Log the stand in stages. Skid the windfalls first, then fell and skid the rest of the stand.

  What tree species are present? Does the stand contain mixed species or sizes? For example, an overstory of Douglas-fir having an understory of hemlock and cedar may create excessive breakage if the two stories are felled together. In this case, harvesting the overstory independently from the understory may be the best alternative.

  What is the stand density? High-density timber stands—that is, stands having many trees to the acre—tend to have more breakage during logging than sparser stands.

What is the timber size? Other factors being equal, it takes a faller longer to fell and buck larger trees than smaller trees. However, costs per unit of volume (board foot) are much lower for larger trees.

Set up felling patterns in relation to the skid trail and landing locations, especially when conducting a partial cut. (See Figures 6 and 7.) Felling the trees “in lead” (with the butts or tops in the general direction of skidding) can significantly reduce costs during the skidding portion of the harvesting operation. Skid trips will take less time since the skidder can gather a turn quickly with less maneuvering. Less breakage occurs during skidding if the logs are in lead.

Fell timber in lead on gentle terrain that will be skidded with wheeled or tracked machines for ease of operation. One pattern used when two or more cutters are working is called strip felling. Cutters fell strips beginning at the landing, working into the stand. When they finish one strip, the cutters move to the next strip. This method makes it easier to fell the trees in lead and helps the cutters stay a safe distance from each other.

Choose felling methods to minimize log breakage. On steep ground breakage can reduce the net volume by 10% to 15%. It is best to fell trees along the contour of the hill on steep ground (over 35%). This minimizes breakage and keeps the logs from sliding down the hill. Local terrain conditions within the stand, such as gullies or small ridges may require a different felling pattern to minimize breakage.

Other harvesting operations may favor different felling patterns. For example, to cable yard a clear-cut using a grapple, lay the logs perpendicular to the cable road. The level of coordination between felling and yarding operations can influence the total cost of harvesting significantly.

A good way to help the fellers keep track of skid trail locations is to mark the ground using bright survey ribbon or paint prior to felling. This method works well in both clearcuts and partial cuts.

A pattern known as group felling works well in smaller timber to help prebunch the logs for skidding. Cutters fell the trees in groups of three or more. They lay the first tree felled in each group down in lead, and fell the other trees in the group across it. The butts of the felled trees are then off the ground for easy choker setting. This method works particularly well when whole trees will be yarded to the landing.

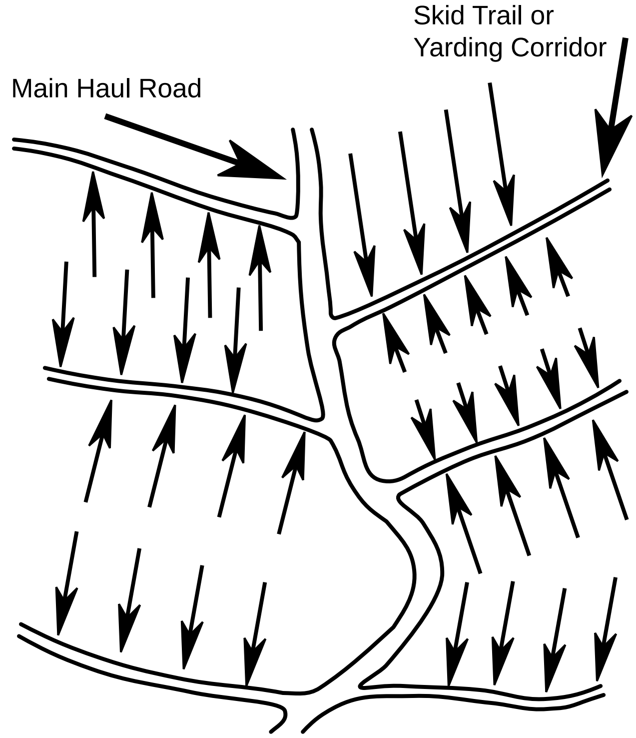


Figure 6 — Parallel skid road pattern. Solid lines show skid roads. Arrows indicate the skid direction.

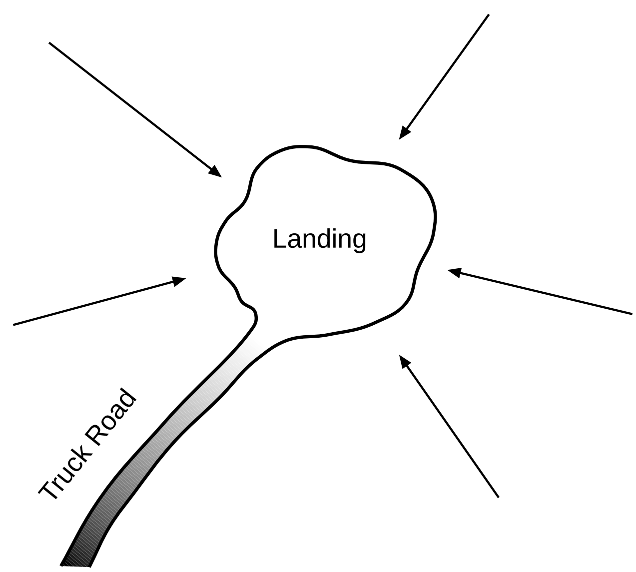


Figure 7 — Radial skid road pattern. Arrows show the skid direction.

Bucking the tree into logs can be done in the woods. Bucking for tree-length or whole tree logging is done at the landing. In either case, the buckers should know the specifications required by the log buyer or mill. Buck for quality, cutting high value logs first. Proper bucking can significantly increase the total value recovered from any given tree. If possible, bunch the logs at the landing, where the log manufacturing process is more controlled than in the forest.

- Trim Allowance
  Trim allowance is an amount of extra length left on each log for trimming ends at the mill. Specifications depend on the purchasing mill, but generally are 6" for a 16-foot log and 10" for a 32-foot log. Leave the proper amount of trim on the log. Proper measuring is a must. Other products can be sold from limbs, tops, and small trees. Poles, fence posts, and firewood are some examples.

- Scaling
  Scaling is the term used to measure log volume. Scaled log measure may be the contractual basis for payments made. Numerous scaling rules exist; each has its own peculiarities known and applied with practice-honed skill by loggers and log buyers. Unless contractually constrained, loggers will buck each tree into logs to their own economic advantage. Material left in the woods, under a different contractual arrangement, might have been sent to the mill at a profit to the landowner. Landowners who sell directly to the mill need to learn the rules, obtain professional assistance, or suffer the consequent loss of potential income.

  Log scaling rulebooks are available from various scaling and grading bureaus. These scaling bureaus provide independent third-party scaling of logs. You may use their services to determine harvested volumes as a basis for payment. Remember, they only scale the logs as delivered. The "measured" volume from any given tree depends on how that tree is bucked. The same tree can produce greatly different "measured" volumes (and values) depending on how it is cut into logs and the scaling rule employed. A written contract developed with knowledge of these scaling rules and the material to be harvested is very worthwhile! Landowners should be aware of potential markets and the value of their timber before harvesting occurs.

- Mechanical Felling Equipment
  Mechanical felling equipment can perform a variety of tasks including felling, delimbing, bucking, and topping. A single machine may do one or more of these tasks. Loggers, on the ground, previously did many of these jobs under very hazardous and fatiguing conditions.

- Feller-Bunchers
  Feller-bunchers fell and bunch trees mechanically with hydraulically driven chain saws, circular saws, or shears. (See Figures 8, 9, and 10.) Sawhead feller-bunchers have replaced many of the shear type machines over the past 10 years. Sawheads cause less damage to the log butt during felling than do shears. Most sawhead feller-bunchers use a circular saw for felling. High speed inertia saws move continuously, even when not cutting. The low speed intermittent sawhead, used commonly in feller-bunchers, employs unique cuplike teeth to fell the tree. Sawheads, like shearheads, generally are limited to trees having a diameter of 22 inches or less at the base.

  Some feller-bunchers are tree-to-tree machines that must maneuver right up to a tree. Others use an excavator as the carrier and maneuver the boom with the sawhead attached from tree to tree. These limited crew feller-bunchers have less impact on the site since they do not travel from tree to tree. The feller-buncher cutting cycle begins with the saw slightly off the ground in the approach to the tree. The operator maneuvers the saw into position directly in front of the tree and lowers it close to the ground. The tool then automatically pushes the saw up to the tree and through the trunk as close to the ground as possible. Accumulator arms clasp the severed tree while the operator moves to a convenient area for bunching.

  Mechanical feller-bunchers generally are much faster than fallers working with chain saws. These machines work most efficiently in small timber (up to about 24 inches DBH) on gentle slopes (below 35%) having relatively uniform ground and few obstacles. Steeper slopes (over 35%) reduce felling production and increase the danger of tipping. However, some newer feller-bunchers are equipped with self-leveling cabs and work productively on slopes up to 50%.

Figure 8 — The typical feller-buncher as used in the Pacific Northwest is track mounted and is designed to work on flat to moderately sloping terrain. Some of these machines have tilting cabs as shown here.

Figures 9 & 10 — A method of commercial thinning now becoming common is the use of a harvester-forwarder combination in what is called a cut-to-length system. The harvester moves through the stand felling, delimbing, bucking and bunching trees selected for harvest (Figure 9); meanwhile a forwarder loads and moves these processed logs to the truck road where it then unloads and sorts the logs into decks for log truck pickup (Figure 10).

The feller-buncher bundles trees for a grapple skidder or cable skidder to pick up. If bunches are appropriately sized for the skidding equipment, productivity can be very high. Grapple skidders are well adapted for skidding bunches prepared in this fashion. Choker equipped skidders also can work efficiently since little time is spent in accumulating a turn.

Feller-buncher advantages:

- Improved felling production.
- Reduce mechanized delimbing and bucking costs since it is easier to work from pile to pile than from stem to stem.
- Realize higher skidding production because of the prepared bunches and low stumps.
- Utilize wood better due to low stumps.
- Carry out mechanized felling on a multi-shift basis (24 hours).
- Improve safety dramatically over conventional felling because the operator is in an enclosed cab.

Feller-buncher disadvantages:

- High capital costs.
- Wood damage and "butt shatter" from the crushing effect of the shears, if used.
- Limited range of stem sizes, typically maximized at 22 to 24 inches at the stump.
- Equipment requires relatively flat and even ground (slopes of 25% or less maximum).

- Harvesters

The harvester fells, delimbs, bucks, and tops trees using a specially designed attachment called a "harvester head." The harvester head is typically attached to the boom of a custom-built rubber-tired carrier having three or four axles (six to eight wheels). The harvester will fell a tree, and as it limbs the tree, place all of the limbs from the tree directly in front of the harvester. When the machine moves through the woods, it rides on the limbs of the harvested trees. This action reduces soil compaction, decreases fire related problems with slash, and helps to decompose the slash more quickly.

The harvester head typically bucks each tree into lengths of 20 feet or less, based on computer calculations programmed in the cab and connected to the harvester head. The computer measures log length and diameter at the top and bottom of the log to determine what log length will maximize value. The operator can override the computer, but typically lets the computer do the work, as it is quicker and more accurate. The harvester places logs to the side of the trail where another machine called a forwarder picks them up.

Harvester advantages:

- More complete utilization of harvested timber.
- Less soil compaction and stand disturbance during harvest.
- Fewer slash problems and no slash concentration.

Harvester disadvantages:

- Higher logging costs—a harvester costs about $450,000 to buy. The logger may charge more to harvest with this machine than with a more conventional system.
- Requires a forwarder to complete the harvest. Harvesters do not work well with conventional skidders or yarders and typically require the use of a forwarder to pick up logs from the forest.
- Limited to slopes of 35% or less.
- Works best in thinnings or partial harvests. These machines are not recommended for clearcuts.

Ground-Based Yarding Systems

Yarding or Skidding

Moving the skidder from the landing to the stump, picking up a load of logs, and then returning the skidder to the landing is called a yarding cycle. In ground-based systems, such as using rubber-tired skidders, this operation also may be referred to as skidding. This yarding cycle is typically broken down into four elements as follows.

The yarding cycle begins at the landing when the unloaded skidder begins traveling out to the felled timber, called the “outhaul.” After the skidder reaches the logs, it collects or hooks them. The logs are now referred to as a “turn of logs.” Once a completed turn has been built, the “inhaul” begins as the machine transports or skids the logs to the landing. Once logs reach the landing, loggers unhook the logs and usually sort them into decks based on species, size, and grades. Once the turn is released, the yarding cycle begins anew.

Other activities that contribute to yarding output but occur irregularly and not as a normal part of the yarding cycle are called supplemental activities. Cleaning debris off the landing or skid trail to facilitate yarding operations would be one such activity.

Delay is nonproductive time and may originate from mechanical or nonmechanical sources. Good equipment and personnel management can significantly reduce the loss of productive time due to delay.

Layout Recommendations

When laying out and building skid trails for ground skidding:

- Minimize the area of land used for trails and landings.
- Plan your skid trails by marking or flagging prior to felling. This helps the fellers know where to fell the trees for easiest skidding. Planning minimizes the total amount of land taken up by skid trails.
- Use the smoothest, firmest ground available.
- Make the trails as straight as possible.
- Avoid obstacles such as hummocks, trees, rocks, and stumps.
- Avoid causing “rub trees” whenever possible. If you must create a rub tree, harvest it near the end of the logging operation. (See Figure 11). If

left in the stand, these trees often have "catfaces," which result in rot and breakage at a later time.

- Cut the stumps in the skid trails as low as possible.
- Fill the low areas with cull trees and slash.
- Do not block streams—particularly intermittent streams—when constructing trails.

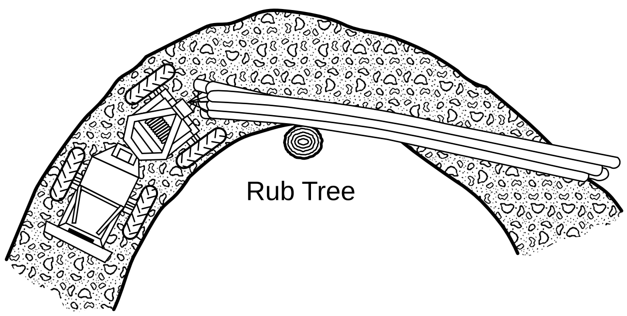


Figure 11 — Rub tree. Similar to a "catface" tree, but done intentionally. Remove all rub trees during harvest operations.

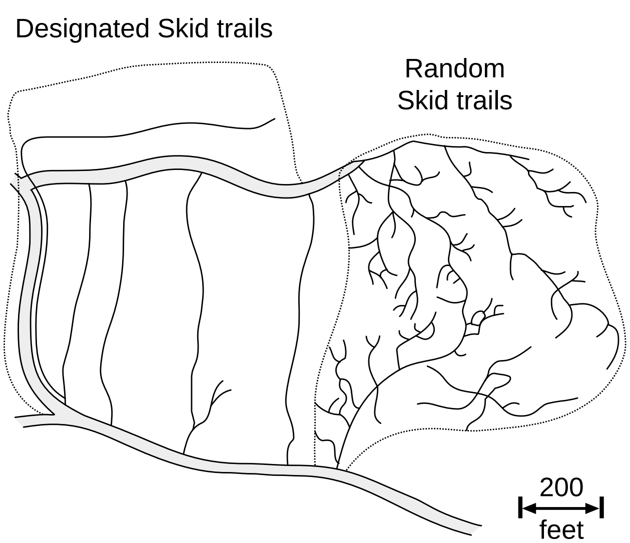


Figure 12 — Ground disturbance comparison between designated skid trails and random skid trails. In this example, random skid trails result in about 25% more ground disturbance than designated skid trails.

Three basic skid trail patterns are random, parallel, and radial. (See Figures 6, 7, and 12). Avoid random skid trails because they usually take up much more land than necessary. One variation of skid trail pattern is called "prebunch and swing." In this method, logs are gathered (prebunched) along the main skid trails either with a skidder, a small winch, or horses. The logs are then skidded down the main skid trail to the landing.

Transporting of felled timber from stump to landing is almost always the most costly part of the timber harvesting operation. Ground-based options often are less expensive than cable or aerial methods. Ground-based yarding systems, summarized in Table 2, are methods of moving logs by tractive effort provided by animal or engine powered vehicles. Horses are the most common type of animal power employed in Washington forests. Mules and oxen also have been used in the past. Today rubber-tired and tracked vehicles typically are used.

The machines used for skidding are diverse. Skidding machines range from specialized machines that forward the logs to a landing to farm tractors modified for logging. Skidders can be wheeled or tracked. Some tracked versions have very low ground pressure and are capable of logging under wet, soft soil conditions that would prohibit the use of other types of skidders. These tracked vehicles include not only the ubiquitous crawler-tractor or "Cat," but also uniquely designed fast-track machines of very high productivity (See Figure 13).

Horses

Horse logging is one of the oldest methods of skidding logs in North America. Considered by some to be obsolete in this age of mechanization, horses can be part of a viable logging system for the small landowner. (See Figure 14.)

The three breeds of draft horses most commonly used for logging are the Belgian, Percheron, and Shire. Horses used for logging usually weigh between 1,400 and 1,900 pounds. A single horse can skid logs in the 60- to100-board-foot range, while a team of two horses can skid approximately twice the board footage per turn. Typical daily production per horse when logging averages 2,000 to 3,000 board feet (MBF).

Horses cannot pull logs up hills steeper than 10%. Uphill skidding tires the horses quickly and should be avoided. Horses should skid logs on flat ground or downhill whenever possible. They can skid down slopes up to 45% (40% in winter). Skidding distances in the 200- to 300-foot range are best, although 500 feet is not uncommon.

Production falls off substantially at longer skidding distances, since the horses must occasionally stop and rest during the skid to the landing. A single horse requires only a 3-foot-wide skid trail. This narrow width is ideal when the stand is thinned, since horse logging does minimal damage to the residual trees.

Plan and flag skid trails for horse logging on the ground prior to logging. Clear flagged skid trails prior to skidding. This is usually done by hand. Cut the stumps around the skid trails as low to the ground as possible to prevent hang-ups. Remove branches and brush from the skid trails to protect horses from injury. Avoid making trails straight down the hill, as the trail will channel runoff water and cause erosion.

Horse logging advantages:

- Horses cause little soil disturbance compared with other skidding methods. Horses can safely log environmentally or visually sensitive areas, such as streamside management zones, scenic roadways, and homes.
- Horses are quiet, producing no machinery noise or diesel fumes.
- Draft horses are inexpensive to own and operate compared with mechanized equipment.
- Horse teams can work in dense timber and cause little stand damage, making them an ideal choice for frequent light thinning.

Horse logging disadvantages:

- Low production. Each horse can skid only 2 to 3 MBF per day; consequently the cost per MBF is high compared with other yarding systems.
- Limited payload capacity. Large timber (above 24-inch DBH) may have to be bucked into less valuable short logs to stay within the skidding capabilities of the horses.
- Limited skidding distances. More roads may be required than with other skidding systems.
- Inability to leave horses untended at the end of the day. Horses must be cared for 24 hours a day, 365 days a year.
- Inability to work on steep slopes.
- Inability to work in snow more than 2 feet deep.
- Horses need to rest.
- When injured, horses require time to heal.
- Limited availability depending on the area.
- Possible contamination of sensitive areas with feces.

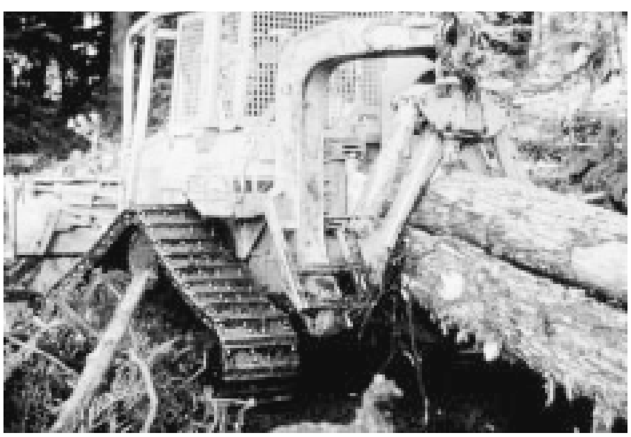


Figure 13 — A crawler tractor is among the most versatile of machines. When equipped with winch and chokers or a grapple as shown in this picture, it can be used for yarding. Wide, low ground pressure tracks reduce soil compaction.

Figure 14 — Log size and yarding slope and distance limit horse logging but when feasible it can provide very low environmental impacts to a site.

Rubber-Tired Skidders

Rubber-tired skidders are machines for skidding trees and logs out of the woods. (See Figure 15.) They may be modified farm tractors or machines designed specifically for logging. Like other ground-based systems, rubber-tired skidders can operate in a variety of silvicultural prescriptions. They are well-suited for commercial thinning or other partial cuts on gentle ground.

Rubber-tired skidders usually cause more soil disturbance than other types of skidding equipment. Repeated travel over the same skid trail can produce deep ruts and a high degree of soil compaction. Do not use skidders on sensitive soils or closer than 100 to 200 feet to streams depending on stream size. Reduce soil disturbance and skid trail density by restricting operations to the drier times of the year and by using directional felling. (Figures 16 and 17.) Minimize damage by having machine operators stay on skid trails and pull the winch line 35 to 70 feet rather than maneuvering the skidder to each log.

The machines designed specifically for logging usually are four-wheel drive, powered by 80- to 180-hp diesel engines, having a 6- to 8-foot blade mounted in the front for minor clearing and grading of skid trails and decking of logs at the landing. They are articulated (hinged in the middle) to improve maneuverability.

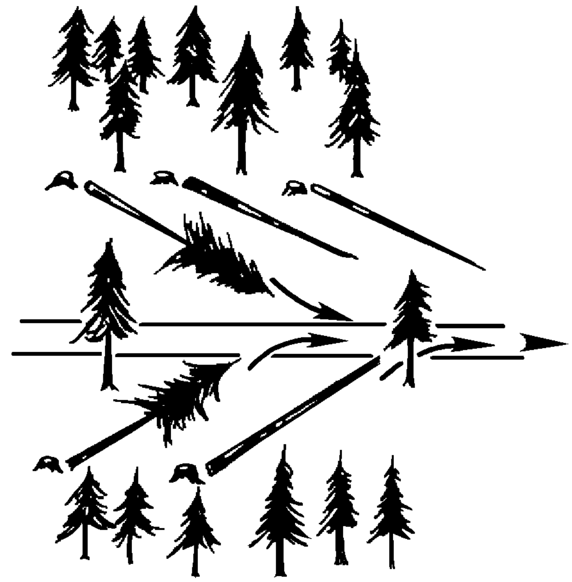


Figure 16 — Directional felling with tree tops toward the skid trail. The arrows indicate skidding direction. This method works well with smaller timber.

Figure 15 — The typical rubber-tired skidder will provide very economical yarding in a variety of silvicultural prescriptions. The use of a cable winch and chokers as shown in this picture increases machine versatility and reduces soil compaction compared with using the same machine equipped with a grapple.

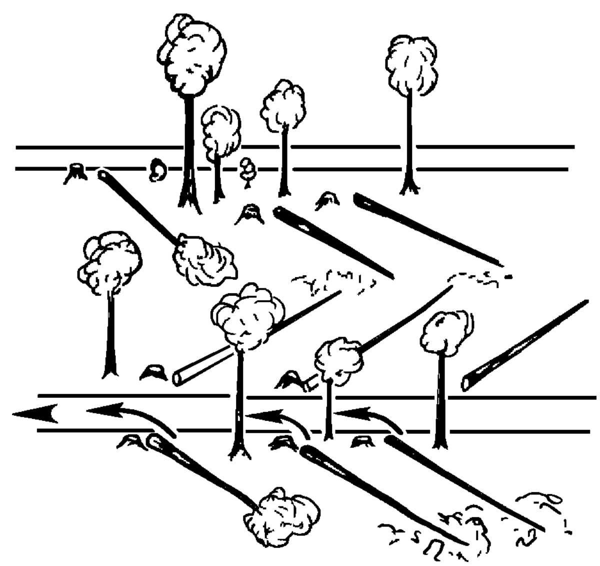


Figure 17 — Directional felling with the butts of the trees toward the skid trail. This method is recommended for larger trees.

Skidders may be either cable or grapple equipped. Cable skidders have a winch drum holding 75 to 150 feet of cable called the bull or winch line. The bull line can run directly to the logs or, more commonly, through an integral arch mounted on the machine. An integral arch helps take the front end of the logs off the ground. This lift reduces friction between the logs and the ground, reduces soil disturbance, and improves traction by transferring part of the log weight to the skidder.

Several chokers 20 to 25 feet in length are attached to the end of the winch line by a shackle. Chokers, formed into a noose around the logs, then pull the logs out of the woods. (See Figure 18.)

Hooks and shackles is the most common method of attaching chokers to the winch line. (See Figure 19.)

Grapple skidders have a set of hydraulically operated hinged pincers behind the machine. The operator lowers and closes them over a log or group of logs. When the turn is skidded, the grapple rather than a choker holds it together.

Grapple skidding works best on prebunched logs. The cycle time is greatly increased for logs that are not prebunched, because of the difficult maneuvering often required to collect a full turn of logs.

Manpower requirements for wheeled skidders are low—just an operator for each machine on the job. The operator usually sets chokers behind the machine. If the skidding distances are long, a choker-setter sometimes is used. The feller can help set chokers. The choker-setter selects the logs that will make up the turn, directs skid road location, and selects the path the logs will travel as they are accumulated for a turn. Skidding machines equipped with grapples do not require choker-setters since the operator controls the grapple from the cab of the skidder. This feature helps give grapple skidders faster cycle times than cable skidders in larger timber or where the logs have been prebunched. Grapple equipped skidder operations are inherently safer than those using chokers since no one need be on the ground in an exposed position.

Wheeled skidders advantages:

- High production rates. A wheeled skidder can move a given quantity of wood twice as fast as a crawler tractor.
- Long skidding distances. The high speeds allow loggers to skid long distances, up to 300 feet, and concentrate more logs on a single landing rather than on several smaller landings.
- Operate profitably where low volumes per acre are to be removed.

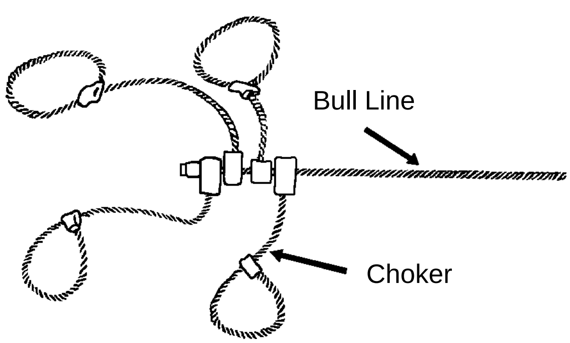


Figure 18 — A multiple choker assembly. Use chains or steel wire to attach chokers to the winch line.

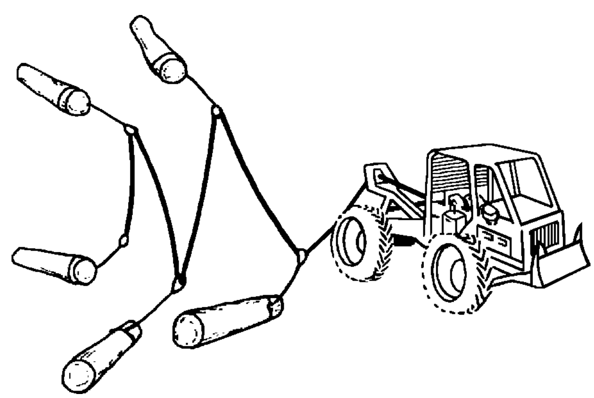


Figure 19 — Chokers may be attached to the winch line by sliding hooks. A ferrule at the end of the line keeps the chokers from sliding off.

- Lower logging costs than any other system on favorable terrain within their normal yarding distances.
- Work in both partial harvests and clearcuts.
- Excellent stream protection if planning and supervision are good.
- Choose their own skid trails using a minimum of road building. This can result in up to 60% savings in trail building costs over crawler tractor costs.
- Relatively low capital investment and small crews.
- Low move-in/move-out costs.
- Excellent availability throughout Washington.
- Adaptability from farm machinery in some situations.

Wheeled skidder disadvantages:

- Unsuitable for operations on wet and easily compacted soils.
- Limited uphill skidding capability.
- Expose mineral soil on 20% to 25% of the area logged.
- Limited to gentle downhill slopes (below 35%) depending on soil conditions and moisture conditions.
- High potential for damage to residual timber in partial cuts or thinning.
- Show increasing costs and environmental impact where groundcover obstructions (stumps, cull logs, rock outcrops) and broken terrain are present.

Tracked Skidders

Tracked vehicles also are used for skidding logs out of the forest. They range in type from the familiar crawler-tractor or “Cat” to the specialized high speed tracked skidder. (See Figure 13.) Manpower requirements for tracked vehicles are low—just one operator for each machine on the job.

Crawler tractors commonly skid the logs behind them using chokers and an integral arch, although drawbar skidding (dragging the logs with both ends on the ground and chokers attached directly to the drawbar or winch) is also done. As with wheeled skidders, grapples are available. Grapples eliminate the need to set chokers but work best on prebunched logs.

When using a choker-setter over long skidding distances, it is best to have several sets of chokers. This allows the choker-setter to pre-set chokers on the logs for the next turn. Pre-setting chokers minimizes the hooking portion of total cycle time, resulting in higher production.

Compared with wheeled equipment, crawler tractors are slow, but they can pull much larger payloads and are able to work under poorer soil conditions. This capability is particularly true of the high speed tracked skidders. Crawler tractors also can be used for other operations, such as road, skid trail, and landing construction. Tracked vehicles are suitable for a variety of silvicultural prescriptions. Given favorable terrain and soil conditions, crawler tractors work well in partial cuts and clearcuts.

Crawler tractor advantages:

- Low total cost system considering the many functions that this equipment can perform.
- Uses small crews.
- Can pull large payloads.
- Exerts less ground pressure than wheeled skidders, resulting in less soil compaction. Can operate on wet ground unsuitable for wheeled skidders.
- More stability than wheeled vehicles.
- Operates in stands where low volumes per acre are to be removed.
- Works well in a variety of silvicultural prescriptions.
- Useful for a wide range of operations, such as road, skid trail, and landing construction, plus site preparation brush piling.
- Available throughout most of Washington.

Crawler tractor disadvantages:

- High initial investment.
- Slower than wheeled skidders.
- Limited uphill skidding capability (10%-15%).
- Downhill skidding limited to gentle slopes (below 35%), depending on soil and moisture conditions.
- Exposes mineral soil on one-fifth to one-quarter of the area logged. (High speed tracked skidders can have considerably less impact on the soil).
- Potential for damage to leave trees is high in partial cuttings, although removing the tractor blade can reduce this.
- Groundcover obstacles (stumps, cull logs, rock outcrops) and broken terrain can increase costs and the impact of individual skid trails.
- Rocky terrain increases maintenance costs.

Forwarders

Forwarders typically work with a harvester. The forwarder moves the logs created by the harvester to a roadside location, where they are either loaded onto a truck for transport to a mill, or stored on the side of the road for later delivery to the mill.

The forwarder is a rubber-tired machine with six to eight wheels. (See figure 10.) Forwarders typically travel over the slash mat created by the harvester (see previous section on felling). They are equipped with a grapple loader and a bunk where the logs are placed. When the forwarder reaches a pile of logs created by the harvester, the operator loads the logs into the bunk with the attached grapple loader. Once the bunk is full, the logs are forwarded to the roadside where they are off-loaded.

Logs carried in the forwarder bunk during transport never touch the ground during travel. This reduces the amount of dirt and debris on the log and, more important, reduces the amount of disturbance to the soil during log transport. The large number of wheels supporting the load, the machine traveling on a slash mat during operation, and the load never touching the ground during transport help to limit the amount of soil damage caused during harvest with this machine.

Forwarders can carry loads of 8 to 15 tons, depending on the size of the forwarder. Larger capacity forwarders have a more significant impact on the site than small capacity machines. Average forwarding distances can reach a mile or more, primarily because of the large load capacity of the machines.

Forwarder advantages:

- Damage less soil than other machines, particularly skidders.
- No need for landings, as all log processing is done in the woods. The logs are simply piled at road-side for reloading and transport to the mill.
- No debris or dirt stays on the logs to affect mill handling and processing operations.
- Long forwarding distances suggest the need for fewer trails.

Forwarder disadvantages:

- Limits on use—slopes must be less than 30%.
- Must be used with a harvester to be cost effective and to minimize site damage.
- Very expensive to own and operate.
- Mill must be able to unload and handle logs having an average length of 20 feet or less.

Modified Farm Equipment

Farm tractors can be modified and used as wheeled skidders. These modifications usually include a logging winch, roll-over canopy, a blade, belly pan protection, valve stem protection, wheel chains, and wheel weights. Chokers may be hooked directly to the drawbar, but this is an inefficient means of attachment.

Cable Systems

Unlike mechanized ground skidding, where a moving vehicle goes out to the logs and pulls them to the landing, cable systems use a stationary machine, or yarder, that pulls the logs to the landing by means of steel cables (referred to as wire ropes). More common cable systems are summarized in Table 3.

Cable systems are feasible regardless of ground steepness. They can log on soft or wet ground that a ground skidder would be incapable of traversing.

Cable systems require more technical knowledge and skill than do ground skidding systems. They also require more intensive planning than ground skidding. Planning is a mixture of office work combined with field reconnaissance to verify and possibly modify the paper plans. Good planning is essential since poor cable system location results in extremely expensive logging.

The road system for cable logging must be planned, located, and constructed with the particular cable system in mind. The loads and forces on the intermediate supports and anchors must be within working limits; this includes a safety factor of three for most elements of the system. State licensed forest engineers usually do these calculations. The use of programmable calculators and desktop computers with specialized software greatly reduces the cost and time required for this design work.

Office calculations always are checked in the field. Critical cableways are marked on the ground, with tail trees and intermediate support trees (when used) marked to prevent accidental felling. An experienced cable logger can benefit by running a field check of the terrain and logging plan before any timber is cut. This check can prevent felling timber out of lead, and felling tailspars by mistake.

Highlead and Jammers

A standard highlead operation consists of the following operating lines: a mainline, used to pull the logs and rigging to the landing; a haulback line, used to pull the mainline rigging back to where the logs will be hooked to the rigging, and a strawline, used to pull out the heavier lines (See Figure 20.). The highlead is not a skyline system. (See next section.) In highlead logging the lift comes from a metal or wooden spar. The spar height and terrain limit the amount of lift supplied. In the Northwest, highlead is a very popular logging system because it is reliable, simple, and can be run with only two drums (winches) on the yarder. Highlead yarding is best used in clearcuts. In partial cuts the cost of this system can be very high due to long cable road change times and the many delays due to hangups. Damage to the residual stand is severe with this system.

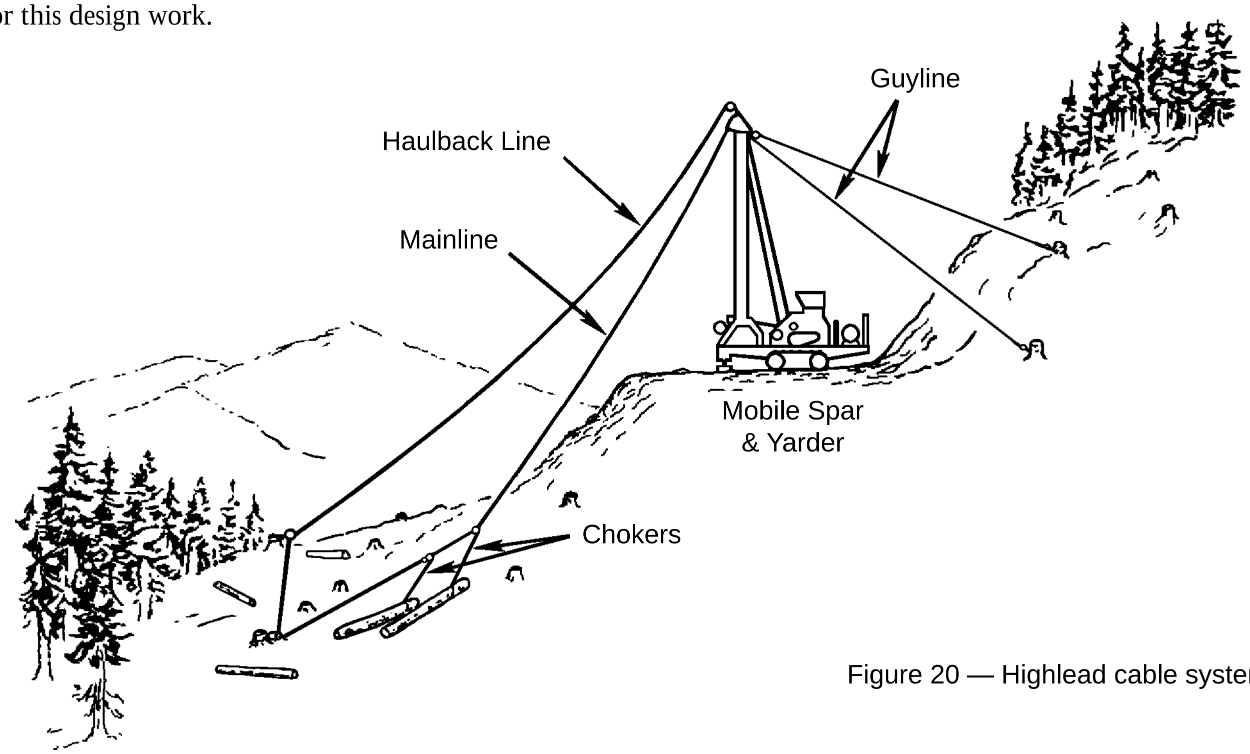


Figure 20 — Highlead cable system.

Figure 21 — Small, highly mobile cable yarders can provide economical yarding of smaller logs on steep ground with minimal impacts.

Highlead systems may cause unacceptable damage to soil when the logs plow up the ground on their way to the landing. Yarding distances are limited in comparison to skyline and helicopter systems. Downhill and sidehill yarding distances are generally less than uphill distances.

Jammers are usually small, two-drum yarders having a short pole or A-frame mounted on a flatbed truck. Often they are shop-built. Jammers most frequently operate as highlead yarders, though in single-drum yarders the choker setter pulls the mainline back out to the logs by hand. These single-drum jammer systems are limited to short yarding distances (Figure 21).

Running Skyline

This system uses a combined skyline/haulback line and a mainline to support the turn of logs and carriage. (See Figure 22.) The skyline/haulback line and main-line move in and out with the carriage. The yarder often has an interlocking mechanism that allows drums to turn at different speeds while maintaining skyline tension and achieving efficient equipment operation.

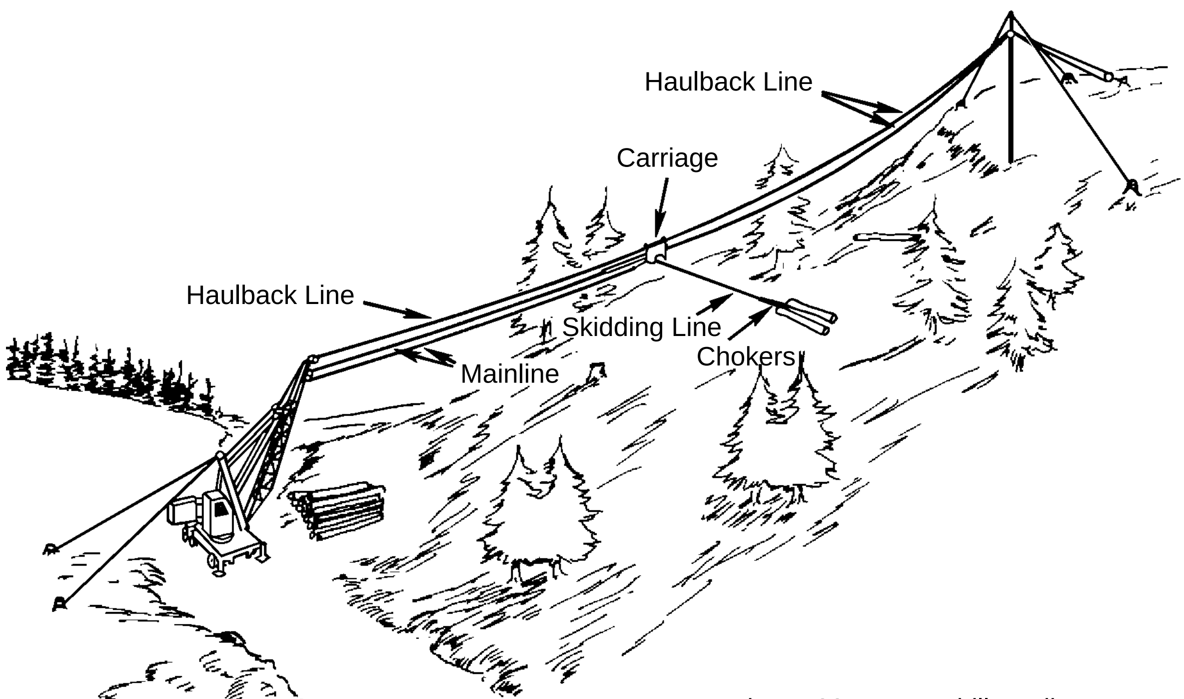


Figure 22 — Downhill yarding system with a running skyline.

Some highlead yarders can be rigged for a simple running skyline system called a Grabinsky. During inhaul of the turn, the yarder operator rides the brakes on the haulback drum to maintain skyline tension. This braking action not only decreases the useful horsepower of the yarder but also increases fuel consumption and wear and tear on the yarder. Running skylines with slackpulling carriages are suitable for both clearcutting and partial cuts (thinning).

Skyline Carriages

Carriage selection can make a tremendous difference in the cost and potential production capabilities of a particular skyline system. Carriages can be classified into two basic categories—those capable of lateral yarding, and those not capable of lateral yarding. Simple carriages have chokers attached directly to the carriage. The lateral reach from the skyline is limited to the choker length, unless another line is used to deflect and pull the skyline to one side (side blocking). An open-sided skyline carriage is shown in Figure 23.

Slack-pulling carriages are able to spool a skidding line out from the carriage or pull out the mainline for lateral yarding. For uphill yarding with small systems, the slack may be pulled by hand. When yarding with larger lines, some carriages have a skidding line that may be spooled out by an operating (slackpulling) line powered from the yarder. Hydraulic and mechanical devices in the carriage that store up energy as the carriage moves along the skyline also are used to pull slack. Some carriages are even equipped with small self-contained diesel engines or electric motors right in the carriage. The size and weight of self-powered slack-pulling carriages (up to 7,000 pounds) restrict their use to large skyline systems.

A second distinguishing feature of a carriage is whether or not it can clamp to the skyline. A carriage that can be clamped in one spot during lateral yarding is particularly useful in partial cuts. Carriages may be clamped by hand, either with a hydraulic or spring-loaded clamp or by positioning a fixed stop device on the skyline. Other clamping mechanisms work by time sequences, radio controls, or cable direction changes. Tightening operating lines from both directions also can hold the carriage in place.

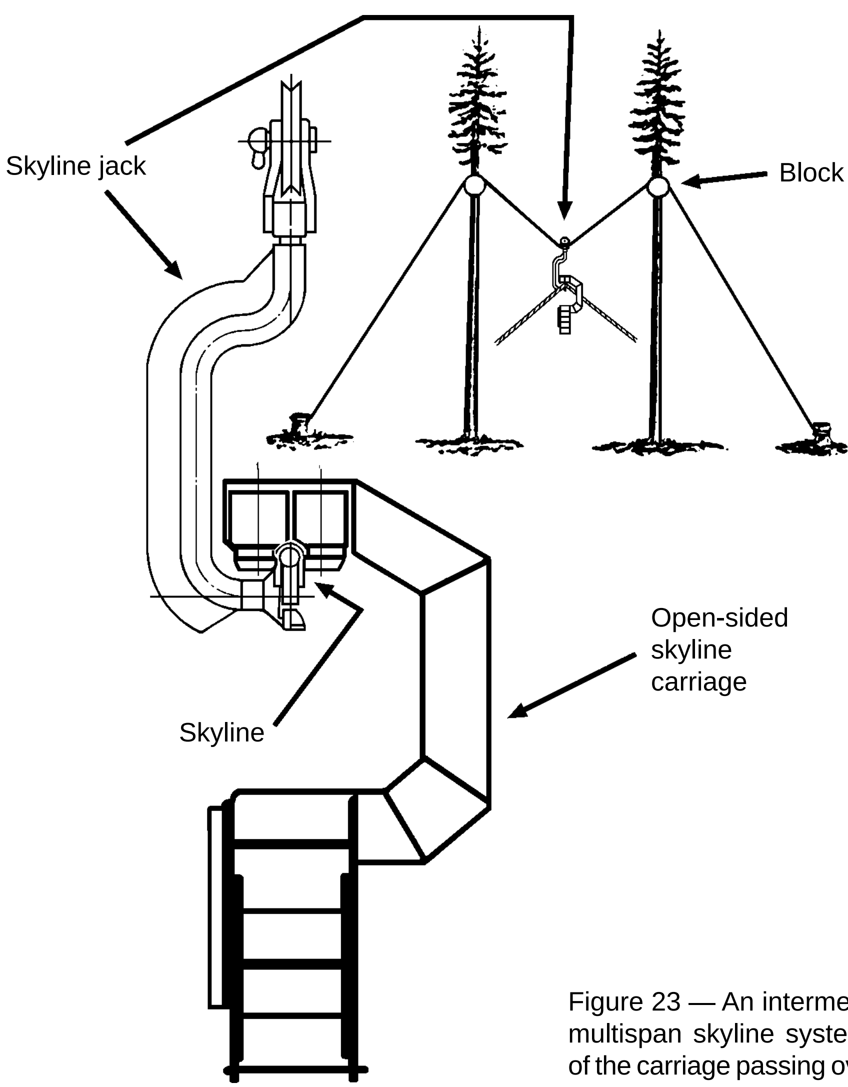


Figure 23 — An intermediate support for a multispan skyline system showing details of the carriage passing over the skyline jack.

Carriages may cost from about $500 to more than $50,000 for models with built-in power plants for pulling slack.

Skyline

Skyline yarding systems differ from highlead in that the skyline is the major load-bearing line; it provides most of the lift to a turn of logs. A simple block or a more sophisticated "carriage" rides on the skyline. The sag of the skyline relative to the straight line drawn between its points of attachment at the headspar and tailhold determines the amount of lift it can safely provide. The height of the headspar (and tailspar if used) helps determine the available lift across any given ground profile (see Figure 24). Generally the more sag (deflection), the greater the turn weight that can be lifted safely. Clearly the shape of the ground profile below the skyline is of great importance. Convex slopes are very difficult to log at any distance with cable systems, even skylines, unless intermediate supports are used. Special carriages often are required for specific purposes such as passing intermediate support jacks (See Figure 23).

A mainline pulls the carriage and logs into the landing along the skyline. A haulback line may be used to pull the carriage back, although gravity return of the carriage is common. Some skyline systems can be used on a two-drum yarder, but most require at least three drums. Skyline systems can be very complex and difficult to set up, having attendant possibilities of mechanical breakdowns within the system. Some skyline systems are as simple and reliable as highlead, however.

Standing skyline

In this system the skyline is anchored at both ends, leaving a fixed length of wire rope extended (See Figure 25). The skyline may be anchored separately from the yarder, or one end may be "dogged" on a yarder drum with a locking ratchet and pawl.

In this system the skyline length is not changed during the yarding cycle. A standing skyline may be suitable for both clearcutting and partial cutting. The yarding equipment can be more expensive and difficult to move and set up than highlead.

Live skyline

As the name implies, the skyline cable moves during a yarding cycle (See Figure 26). The skyline is lowered (slacked) to pick up a turn of logs; it is then raised (tightened) so the logs will have sufficient lift while they are pulled into the landing. Many yarder/towers

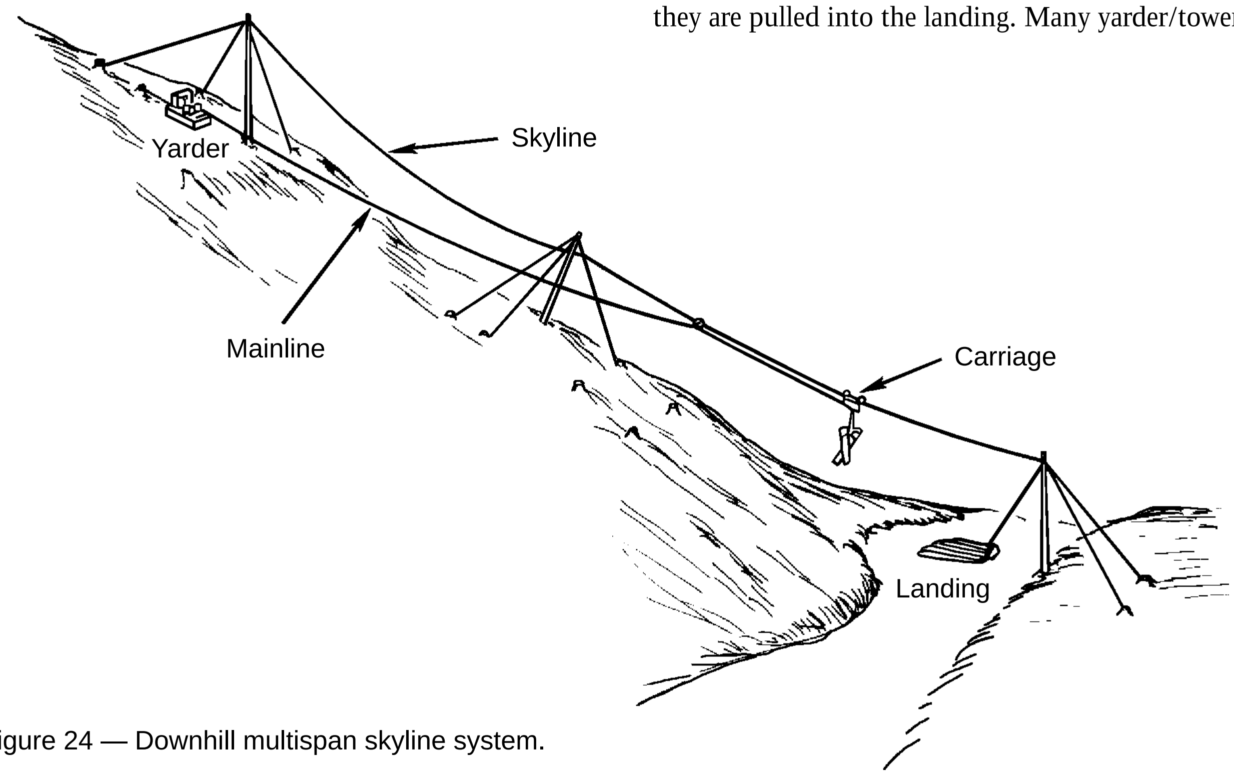


Figure 24 — Downhill multispan skyline system.

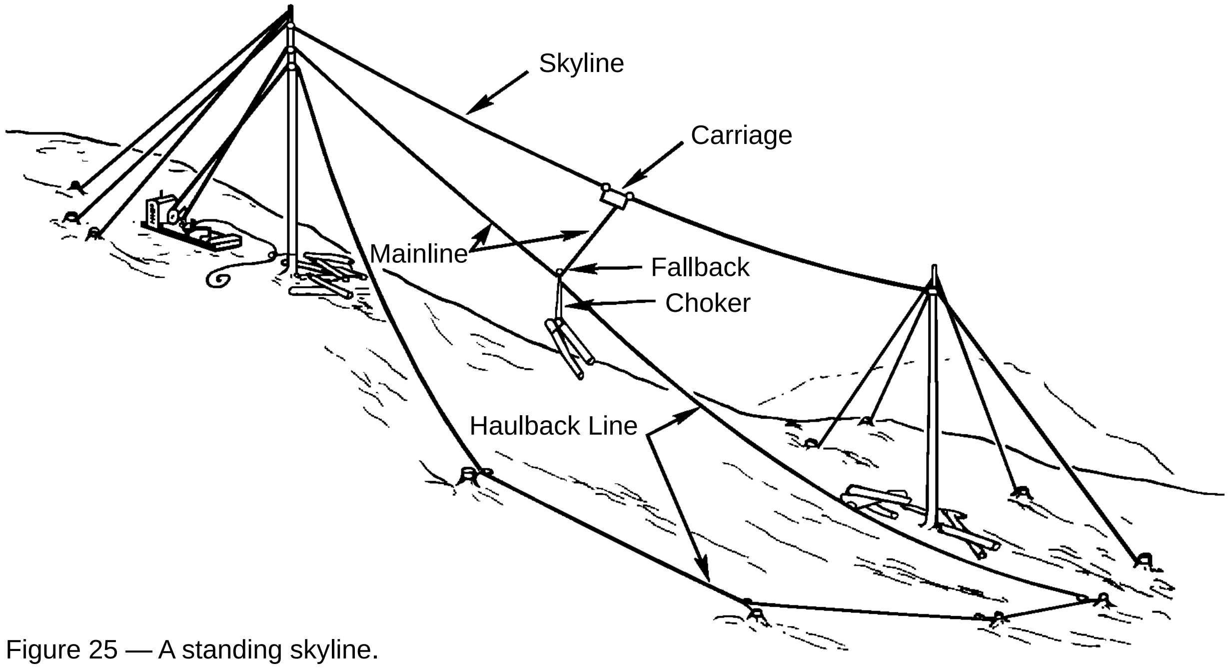


Figure 25 — A standing skyline.

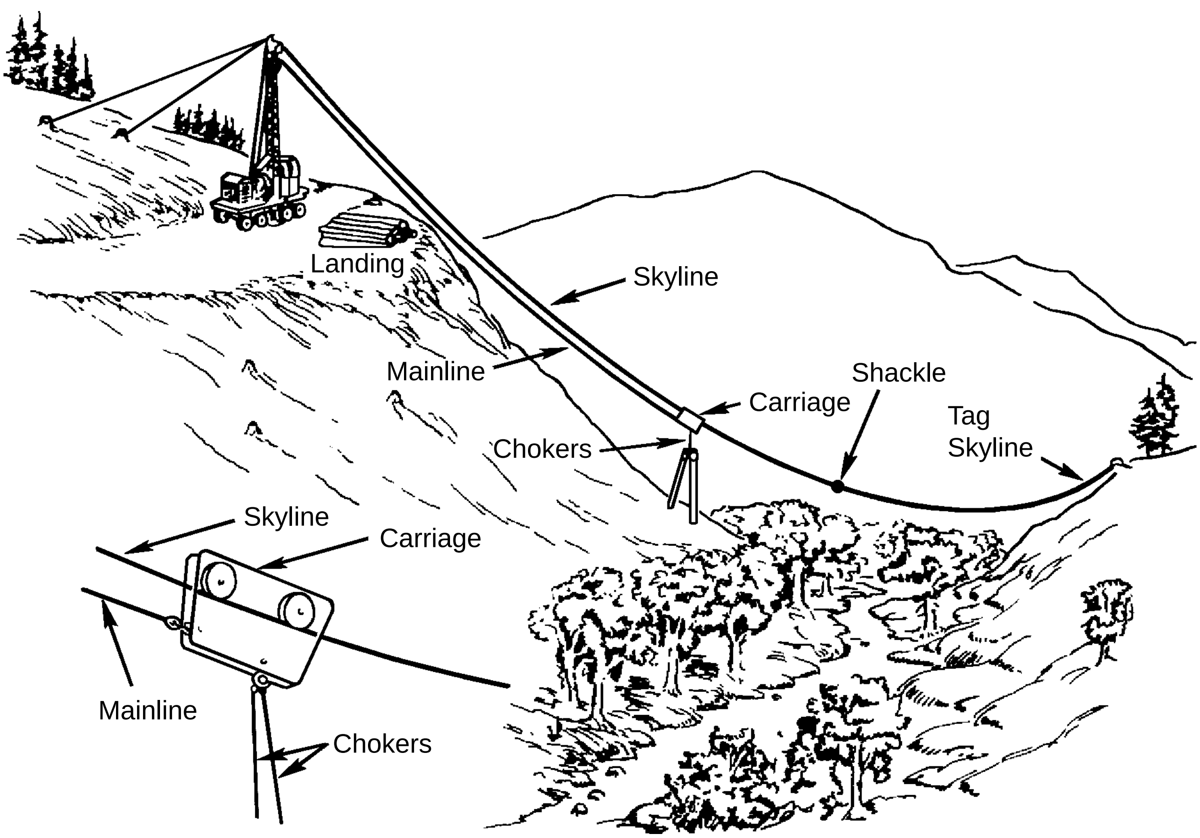


Figure 26 — A live skyline configuration, shotgun configuration.

built for highlead operation can be modified for use as a live skyline system, but a professional engineer should verify such modifications. Guying requirements for the skyline system also are much more demanding. The logger must be aware of these safety-related changes. While live skylines can be used for both clearcutting and partial cutting they require suitable terrain.

Terrain and Skyline Relationships

Access road location will determine harvest feasibility. Consider the timber and terrain scheduled for harvest in Figure 27. The stand is valuable and large enough to be harvested in a number of ways that provide protection to the soils and stream. If, as in Figure 27, roads can be built on the ridge just below the break in terrain, the gentle terrain on the ridge may be harvested using ground skidding equipment, while the slope can be yarded with a medium-sized skyline system. If the road on the slope may be built, the lower slopes could be harvested with a small skyline system. Matching the proper skyline system to the local conditions and road system is an important decision. Cable systems exist that are adaptable to almost any yarding situation.

Figure 28 represents an interesting challenge to skyline yarding systems. The only road into the area is at the

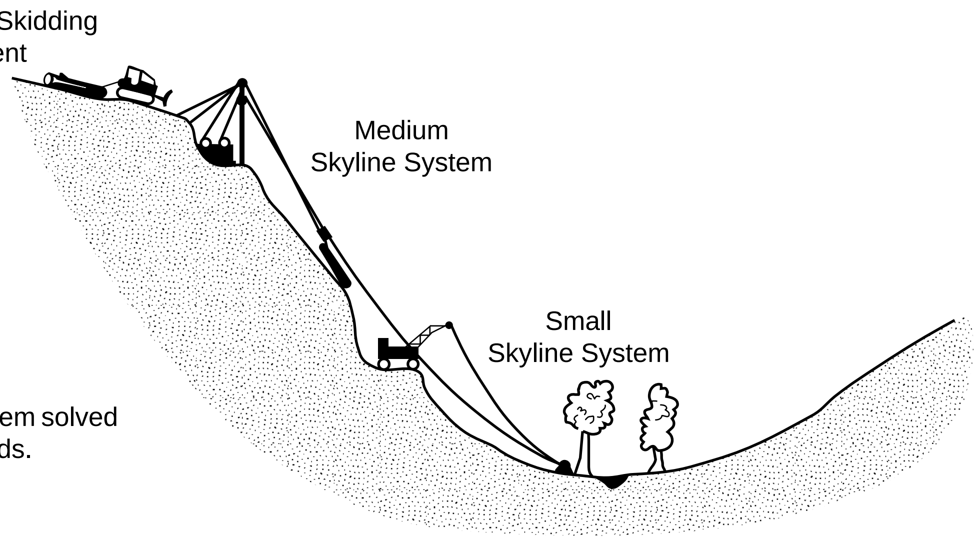


Figure 27 — A harvest problem solved by using two skyline methods.

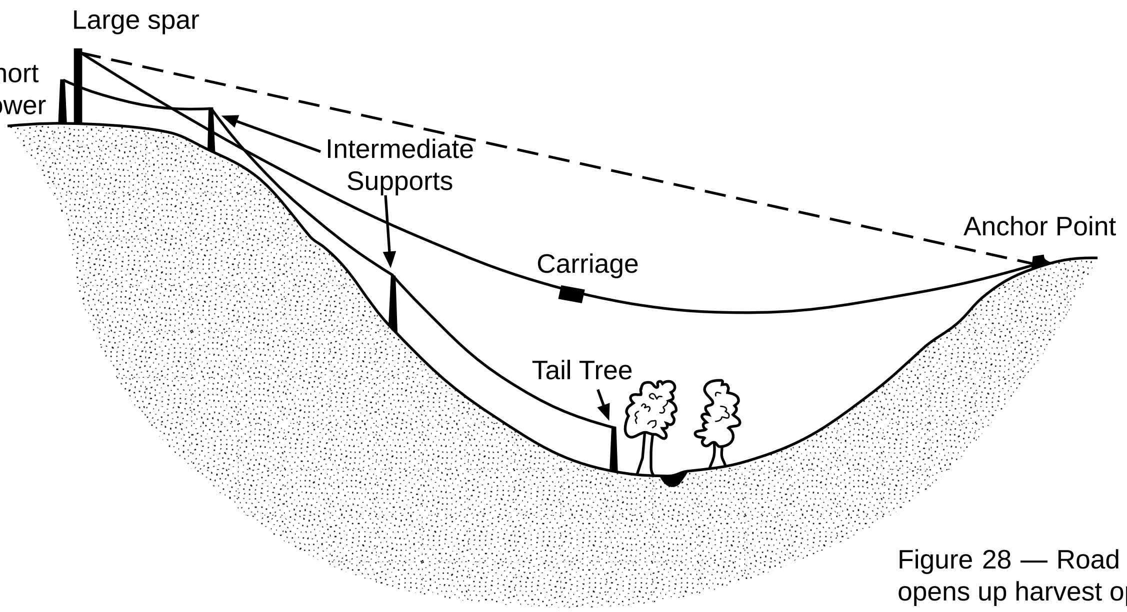


Figure 28 — Road accessibility opens up harvest options.

top of the hill at left. The hardwood buffer strip along the creek must be left undamaged. Additionally, the soils are prone to erosion and require suspending at least one end of the log during yarding to minimize the plowing effect of the dragging log.

Two different skyline methods are shown in Figure 28. A large spar and long-span skyline have been set up on the road and anchored to the far hillside. Using the proper carriage could keep the logs out of the stream buffer. Another method would be the multispan system, using a shorter tower at the landing, a tail tree at the bottom of the hill, and two intermediate supports.

Consider several factors in choosing an appropriate skyline. Examination of some requirements for skyline operations will help. The first consideration is deflection. This is the sag in the load supporting line. It is the primary consideration for a feasible skyline operation. In general, the greater the deflection, the greater the effective payload at each turn. Also, good deflection will help reduce soil damage from dragging the logs to the landing.

Access roads also are important for skyline landing location. Some roads may be too narrow or have curves that are too sharp. Bridges adequate for a large yarder and tower weighing 60 tons may be required.

Skyline anchors are usually stumps or live trees, although heavy equipment and rock bolt anchors are sometimes used. They must be strong enough to anchor the skyline and the three to six guylines that support the tower.

Tail trees at the back end provide extra elevation to the skyline. Intermediate supports provide extra height to clear ground obstacles. Guylines may be required on trees used as intermediate supports.

Timber size and weight are important variables of cable logging. Small skyline systems may be adequate for second growth timber but lack the power to pull out the scattered old-growth log. Such logs may have to be left or cut to fit the machine's capabilities.

Value/volume relationships also affect the system decision. An acceptable cost per unit ($/MBF) may be achieved with an expensive high-volume system producing many logs, or by a small, low production, low-cost system. When setting up a cable road, the fixed cost of rigging is high, requiring enough timber under the cableway to pay for each setup. The setup must be within the system load limit. Cable systems are extremely sensitive to piece size, the number of pieces per turn, and skyline span length.

The environmental performance of cable systems differs. Some systems may be unable to lift the front end of the log, resulting in unacceptable soil disturbance. A system unable to lock the carriage to the skyline during lateral yarding may allow tree damage from lines or rolling logs in partial cuts. Large, high productivity systems may require large landings.

Helicopters

Loggers have dreamed of a skyhook that could descend out of the sky and lift logs to the landing without regard to terrain. The helicopter is a machine that comes close (Figure 29). Terrain, road location, or type of cut seldom limits it. Helicopters are capable of yarding long distances with very high production. (The distance is usually limited by economics.) Payloads per turn range from 1,000 to 20,000 pounds depending on the helicopter model. Site disturbance is minimal since helicopters lift the logs straight up. Even in thinning, residual tree damage is low.

Helicopters are not the answer to all difficult logging operations. They require large landings to drop the logs, adequate room to sort the logs as they come in, and a service area nearby for refueling, maintenance, and nighttime storage of the helicopter. Weather, poor visibility, and high or gusty winds often restrict operability. Altitude and high temperatures can reduce a helicopter's payload by one-quarter or more.

Production costs in helicopter logging are extremely high. Helicopters are expensive and require constant maintenance and inspections. It is not uncommon to have two full-time mechanics on a helicopter logging job. Because the helicopter is capable of high production rates, crew requirements are high. A logging operation with a large helicopter requires 14 to 28 persons.

Helicopters are sensitive to the weight of the turn. To prevent overloading, the logs for each turn are usually selected with up to 150 preset chokers. To stay within the payload weight limit of the helicopter, buck logs for weight as well as quality. Some reduction in log value may have to be accepted.

Helicopter logging is feasible when log value is high and road building costs are very high, or where road building is not possible or desirable because of environmental concerns. The high costs associated with this system require intensive planning and high value, harvestable timber for successful operations.

Loading and Hauling

Most log loading is done using a hydraulic knuckle boom, equipped with a log grapple. This machine comes in rubber-mounted, tracked, or self-loading log truck versions. Track-mounted log loaders are often hydraulic excavators that have had the bucket removed and a hydraulic grapple and “heel” mounted in its place. The grapple forces one end of the log against the heel or brace bar to help steady and control the log being loaded. Hydraulic loaders of this type can load upwards of 20 truckloads a day. They are versatile machines. By changing the boom-stick attachment, operators can use them for road construction, felling, yarding and a variety of other tasks. Attachments are available to convert a hydraulic tracked loader into a cable yarder.

Self-loading log trucks are valuable. (See Figure 30.) They typically have a knuckle boom hydraulic log loader mounted just behind the cab. They can pick up partial loads on small jobs, or load logs on logging jobs too small to justify a full-time loader. Self-loaders decrease the payload and increase the price of the log truck.

Front-end loaders occasionally are used on logging jobs. Some loaders are built specifically for logging. Others are converted from bucket models. Front-end loaders require larger landings than stationary machines. Landings should be flat and firm.

Trucks used for log hauling vary widely in size and load carrying capacity. The most common logging truck used in the Pacific Northwest is the tandem

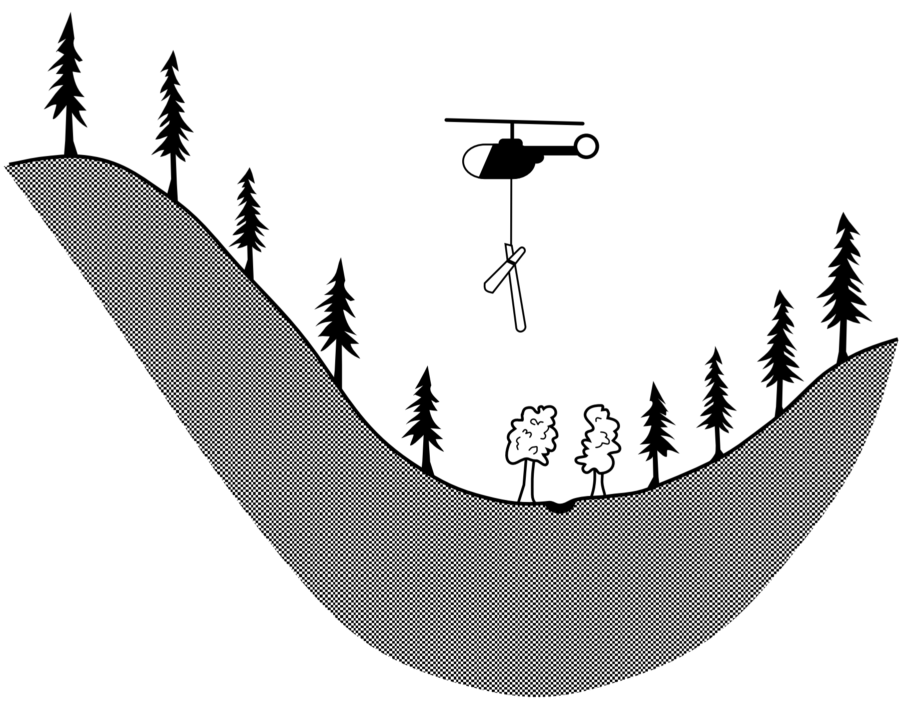


Figure 29 — Inaccessibility often limits harvest operations. Helicopter logging is an expensive alternative.

axle truck with a pole trailer. The trucks are typically powered by 300- to 400-hp turbo-charged diesels.

The pole trailer has two axles and attaches to the tractor with an alloy steel tube called a "stinger," which adjusts to the length of load being pulled. Since the maximum GVW allowed on Washington public roads is 80,000 pounds for trucks of this type, most log trucks are equipped with electronic scales. The scales help the trucker load the truck as near as practicable to the legal limit without being overweight.

Contract Trucking

If you have timber harvested and left at roadside, or if you harvest it yourself, you will need a contract trucker to deliver the wood to the mill. Self-loaders are perfect for these operations, as you do not need a separate loader for the operation. Or, if you have access to a loader, you can use a conventional "eighteen wheeler" to haul your logs. Be sure that, whomever you get, the trailer configuration will safely handle the logs you have harvested, particularly if you are producing logs less than 20 feet in length.

You can negotiate a lump-sum arrangement with the trucker to haul your wood, or pay by the load. Most truckers will charge a rate for the number of "ton-miles" driven, based on the weight and distance traveled to the mill. Expect to pay more per ton-mile when using a self-loader, or negotiate a price to load the logs over and above the cost to deliver the wood to the mill.

A typical tractor-trailer used for log transport will haul about 28 tons of wood per trip. This will vary depending on the weight of tractor and trailer when empty. Self-loaders can haul about 24 tons of wood per load, depending on the trailer configuration and the weight of the loader. A rough conversion of seven to eight tons per MBF can be used to estimate the weight of production and predict how many loads you have at the landing.

Figure 30 — A self-loading log truck with a hydraulic knuckle boom loader can provide an economic means of delivering small harvest volumes to the mill.

Suggested Reading

Internet Resources

http://ext.nrs.wsu.edu/
Washington State University Extension, Pullman, Washington. Extension forestry assistance and educational programs, publications, consulting foresters, log prices.

http://dnr.wa.gov/dnr/base/dnrhome.html
Washington State Department of Natural Resources, Olympia, Washington. Forest Stewardship Program related information.

http://www.loggers.com/
Washington Contract Loggers Association: List of accredited logging contractors.

http://www.cfr.washington.edu
College of Forest Resources, Seattle, Washington: Public service assistance from faculty of professional foresters and forest engineers.

http://www.fs.fed.us/pnw/Prime/
USFS, Pacific Northwest Region: Timberland data for the region.

http://www.treefarmsystem.org
American Tree Farm System

http://www.acf-foresters.com/
Association of Consulting Foresters of America, Inc.

http://www.mrsc.org/mc/_toc/wac.htm
Washington Administrative Code: Includes Washington Forest Practice Rules (WAC 222) and Safety Standards for Logging Operations (WAC 296-54).

http://www.dol.wa.gov/engineers/engfront.htm
Washington State Board of Registration for Professional Engineers and Land Surveyors: List of services provided by the Board.

http://www.safnet.org/index.html
Society of American Foresters: List of certified foresters and various publications.

http://www.wwpa.org/
Western Wood Products Association, Portland, Oregon: Stumpage price information.

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Anon. 2005. *Washington Forest Practices: Rules—WAC 222*; Board Manual; Forest Practices Act RCW 76.09. (Portions revised, various dates) Department of Natural Resources, Forest Practices Division, Olympia, WA. Available online at http://www.dnr.wa.gov/forestpractices/rules/.

Anon. 1997. Safety Standards for Logging Operations (1-97 issue of Chapter 296-54 WAC). Department of Labor and Industries, Olympia, WA. 80 pp. Available online at http://www.lni.wa.gov/wisha/rules/loggingoperations/default.htm.

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Baumgartner, David M. and Donald Hanley. 1996. *Forestry Education and Assistance Programs for Washington Forest Landowners*. (Revised) EB1286, WSU Extension, Pullman, WA. 13 pp.

Hanley, Donald P., David M. Baumgartner and Leila Charbonneau. 1996. *Terminology for Forest Landowners.* EB1353, WSU Extension, Pullman, WA. 40 pp.

Glossary

Belgian, Percheron, Shire—Breeds of horses used to skid logs.

Choker—A noose of wire rope used to skid logs.

Choker-setter—One who puts the chokers around logs in a yarding operation.

Crawler tractor—Vehicle with tracks to skid logs; “cat” (Caterpillar).

DBH—The tree diameter at breast height (4.5 feet above the ground on the uphill side).

Deck—A pile of logs ready for loading and transporting.

Decking—Pushing logs into a pile or “deck.”

Faller (or Feller)—A logger who specializes in felling trees. Also called “cutter” or “sawyer” in some parts of the West. Machine that fells (cuts down) trees.

Feller-Buncher—Machine that fells and gathers trees.

Forwarder—An all-terrain vehicle designed to efficiently move (forward) bunched trees or logs over relatively long distances from the stump to the road.

Grapples—Large pincherlike mechanism on a skidding machine to pick up prebunched logs; sometimes used in place of chokers.

Heel—A brace bar against which a grapple steadies and lifts logs.

Highlead Logging—A system that uses cables rigged to a spar high above the ground to lift logs during yarding.

Jammer—A single winch drum cable yarding system using a wooden pole or A-frame on a flatbed truck to lift logs.

Landing—A place where logs are assembled, processed, and loaded on trucks for transport to mills.

MBF—Abbreviation for thousand board feet.

Prebunch—To collect logs at intermediate staging areas in preparation for the main yarding operation.

Rigging slinger—One who selects logs for the turn and directs skid trail location; a choker setter may do the task as well.

Skidding—Pulling logs with equipment or horses from the stump to the landing.

Skid trail—Route along which logs are taken to landing.

Skidder—One who conducts skidding operation; or, a machine used for ground-based transportation along skid trail.

Skyline logging—A type of cable logging in which stationary cable holds a movable carriage.

Turn—The logs brought to the landing during a single yarding or skidding cycle.

Yarder—Machine equipped with winches to pull the cables of a skyline logging system.

Yarding—Moving logs by cable system from the stump to a landing.

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