

**J. N. Kochenderfer
and G. W. Wendel**

SKYLINE HARVESTING IN APPALACHIA



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Abstract

The URUS, a small standing skyline system, was tested in the Appalachian Mountains of north-central West Virginia. Some problems encountered with this small, mobile system are discussed. From the results of this test and observation of skyline systems used in the western United States, the authors suggest some machine characteristics that would be desirable for use in the Appalachians.

The Authors

J. N. KOCHENDERFER has been employed by the Forest Service since 1960 and since 1967 has worked for the Northeastern Forest Experiment Station's field laboratory at Parsons, West Virginia. He received his bachelor of science degree in forestry from West Virginia University and his master's degree in forestry from Duke University. His major work was in timber management before he went into forest hydrology research.

G. W. WENDEL is a research forester for the Northeastern Forest Experiment Station, stationed at the Timber and Watershed Laboratory, Parsons, West Virginia since 1962. He received a B. S. in Forestry from Iowa State University in June 1951, and an M. F. from Yale University School of Forestry in June 1957.

Before joining the Northeastern Forest Experiment Station, he worked 5 years with the Southeastern Forest Experiment Station, and 3 years with the Southeastern Forest Experiment Station, and 3 years with the New Jersey Department of Conservation and Economic Development.

IN THE Appalachian mountains, most timber is harvested by ground skidding systems. Wheeled skidders are the most widely used machines. A major criticism of skidder operations is the dense road network required to move the logs to landings. Often these road systems are poorly planned, do not protect other resources, and are esthetically unpleasant when viewed in the landscape.

For example, Kochenderfer (1977) measured bulldozed roads on nine skidder- and two jammer-logged jobs in north-central West Virginia. On skidder jobs, road spacing seldom exceeded 150 feet, with one mile of road required to log about 20 acres. On the jammer jobs, where a truck crane was used to yard and load logs, road spacing averaged about 250 feet; here, 1 mile of bulldozed road was needed to log about 31 acres. With a standing skyline cable system, we were able to log about 80 acres from 1 mile of road.

On the Fernow Experimental Forest near Parsons, West Virginia, we tested a standing skyline cable system¹ that might have application in the central Appalachian mountains. The Forest Engineering Project of the Northeastern Forest Experiment Station from Morgantown, West Virginia, cooperated in these tests.

The machine was a URUS,² a small mobile unit made in Austria with a skyline capacity of 1,100 feet of $\frac{7}{8}$ -inch cable (Fig. 1). The unit has a 28-foot tower and a carriage that automatically clamps onto the skyline when stopped. The corri-

¹ For definitions of cable logging terms, refer to the glossary at the end of this paper.

² The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture or the Forest Service of any product or service to the exclusion of others that may be suitable.

Figure 1.—The URUS, the skyline system used in these tests.



dors ranged from 600 to 900 feet long and averaged 789 feet. Spacing between corridors averaged 150 feet. Since the URUS had previously been used almost exclusively in clearcutting, we confined our tests to partial cutting. Average lateral yarding distance under these conditions was 75 feet on either side of the skyline.

We also observed cable systems, including live and running skylines, currently used in the eastern and western United States. Although we recognize that skyline cable systems differ in mechanics and complexity (Studier and Binkley 1974), all can be used in clearcutting and in partial cutting.

Topography

Topography is extremely important in determining the utility of any skyline system because regardless of the system used, there must be adequate clearance between the ground and skyline. In mountain country, skylines operate best on concave slopes, with all logs yarded across the hollows. However, there is a great diversity of topography in the central Appalachians and frequently concave and convex slopes are mixed with small benches and frequent rock outcrops (Fig. 2). With skyline spans of 800 to 900 feet, the URUS needed at least one, and frequently two, intermediate supports to elevate the skyline so that the front ends of logs would pass over obstructions. Slope is important in gravity-feed systems, especially when small and relatively light carriages are used. The carriage must gain sufficient momentum to unspool and drag several hundred feet of mainline cable. In the West, slopes must be greater than 25 percent for these systems to operate efficiently. On lesser slopes and in downhill yarding, power must be used to pull out the carriage and pull slack for lateral yarding.

Unfavorable topography can be overcome to some extent by building roads in the most favorable locations possible. Other measures to counteract it are (1) shortening the skyline span, (2) elevating the skyline block or anchor, (3) increasing the height of the tower, and (4) using intermediate supports. For example, we used a 28-foot tower to log 39 corridors with the skyline block elevated to 30 feet and an average skyline length of 789 feet. Two supports were required on 15 of these corridors, 17 required 1 support, and 7 required no supports. The results of an analysis of the same ground profile data showed that with a 40-foot tower on the URUS, 11 corridors could

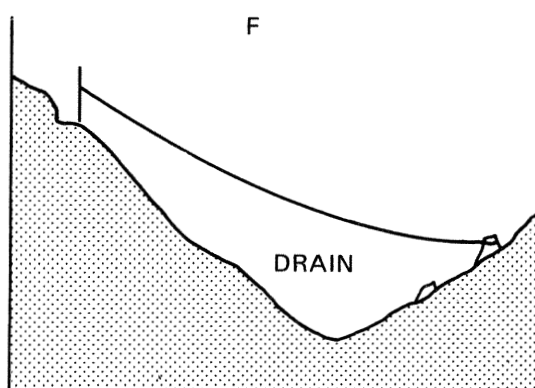
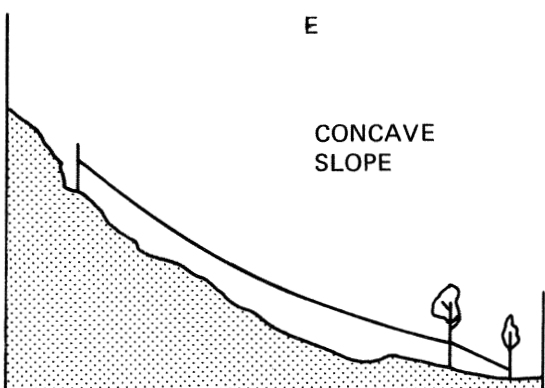
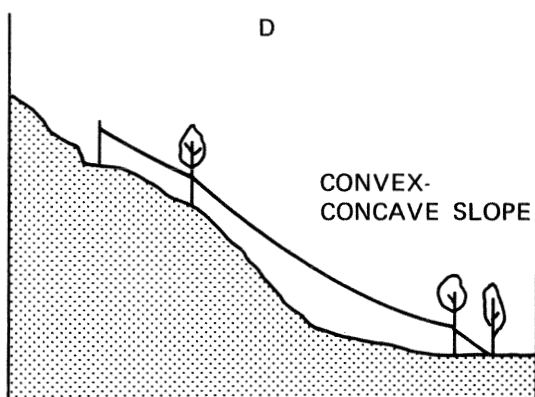
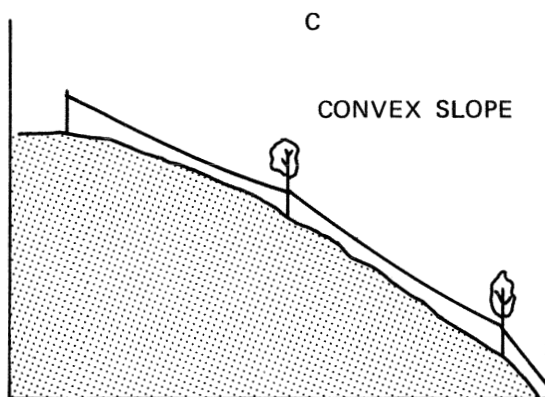
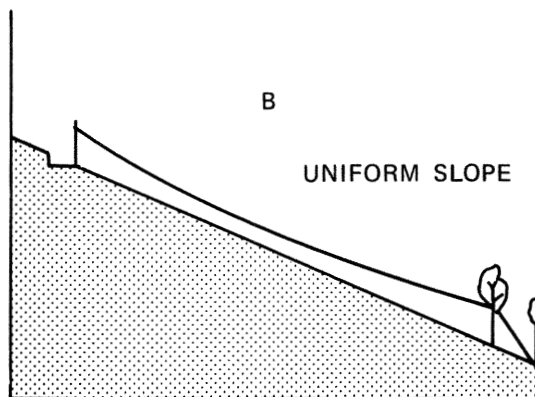
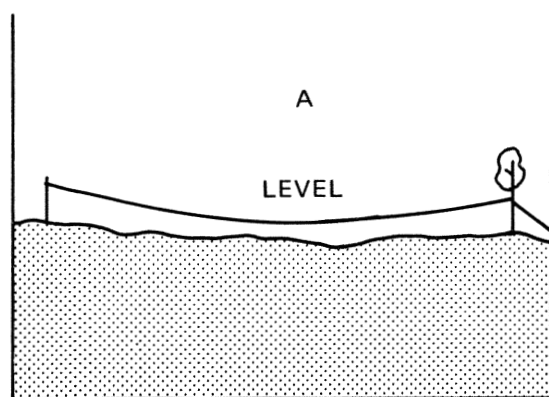
have been logged without supports. By shortening the skyline to 500 feet and using a 28-foot tower, 55 percent or 21 of the corridors probably could have been logged without intermediate supports. By raising tower height to 40 feet and holding spans to 500 feet, we could have logged 85 percent or 33 of the corridors without supports. The slopes we logged averaged 46 percent and were relatively constant convex slopes with numerous rock outcrops up to 15 feet high. As previously pointed out, slopes like these are the least desirable for cable logging. We believe that many spans longer than 500 feet cannot be logged without intermediate supports in the central Appalachians because of topographic restrictions.

Cable logging should not necessarily be restricted to steep land. Many of the skyline systems that we observed had the capability of logging relatively gentle topography. The use of cable systems on gentle slopes (e.g. 30 percent) would eliminate about as many roads as on steep slopes (e.g. 50 percent) because road density is controlled by factors other than steepness. Logging methods, topography, and obstacles such as cliffs, streams, and property lines influence road density. In general the less steep areas in the eastern mountains are often the best timber growing sites. Skyline logging would require a lower road density and damage to the site from compaction would be minimized.

Much of the timber that is logged in the central Appalachians consists of low volume and value stands on steep, less accessible land. The question that has to be asked: Can this timber be logged with equipment that is often more expensive to operate than conventional ground skidding systems?

Topography is also important after the logs have been yarded to the spar. If the yarder is on a ridge top, logs can usually be dropped without sliding downhill, and they can be moved from beneath the skyline with a tractor or skidder. On midslope roads in steep country, there is usually insufficient decking space in front of the yarder and logs tend to slide down the slope. Where fixed towers are used, logs must be held by the yarder until they are secured by a cable from a tractor or skidder. In the West, hydraulic grapple loaders are used to remove logs from in front of the yarder. However, if yarders are equipped with swinging booms, logs can be swung and decked parallel to the road or on the road.

Figure 2.—Types of skyline situations.



Skyline Planning

Planning is an integral part of any logging job, regardless of the system used, but our experience and that of others has shown that cable systems demand more thorough planning than others (Burke 1975, Studier and Binkley 1974, Lysons and Wellburn 1976). The first step is to obtain the best topographic maps and aerial photographs available. From these, an access system and a rough logging show can be outlined. In the eastern United States, the U. S. Geological Survey 7½-minute quadrangle sheets which have a contour interval of 20 or 40 feet are readily available. Although they show none of the small obstructions such as rock outcrops and small benches, they are sufficiently detailed for determining road locations, landings, rough ground profiles, and corridor locations. The area should then be reconnoitered and roads, landings, and corridor locations flagged out.

Besides the topographic and environmental considerations, timber volume and value per acre are very important. The cut per acre must be carefully considered because it is probably the single most important variable that affects yarding costs. Most experience indicates that skyline logging, at least in partial cuts, is more expensive than conventional ground skidding (Aulerich and others 1974).

In the eastern United States, ownerships are relatively small and access to a given tract of timber is often controlled by property lines and topography. These characteristics of the tract to be logged must be considered when selecting the machine for the job. Mobility, rapidity of setup and tear-down, and ability to work from narrow roads are important factors to consider on small tracts.

Corridor Location

From the planning map and reconnaissance of the area, we can determine the number, length, and direction of corridors needed to harvest the various parts of the sale area.

Because topography changes over relatively short distances in the Appalachian mountains, we believe that most corridors longer than 400 or 500 feet will have to be laid out on the ground before logging when partial cutting is used. Mixtures of

convex and concave slopes, frequent rock outcrops, and dense vegetation all limit visibility, which makes "eyeballing" corridor center lines difficult or impossible for long distances. In clearcuts, where preliminary information indicates that intermediate supports are not required, it seldom is necessary to mark corridor locations on the ground. Suitable tail trees are usually visible around the perimeter of the clearcut where there are no standing trees to interfere with passage of the carriage or tensioning of the skyline.

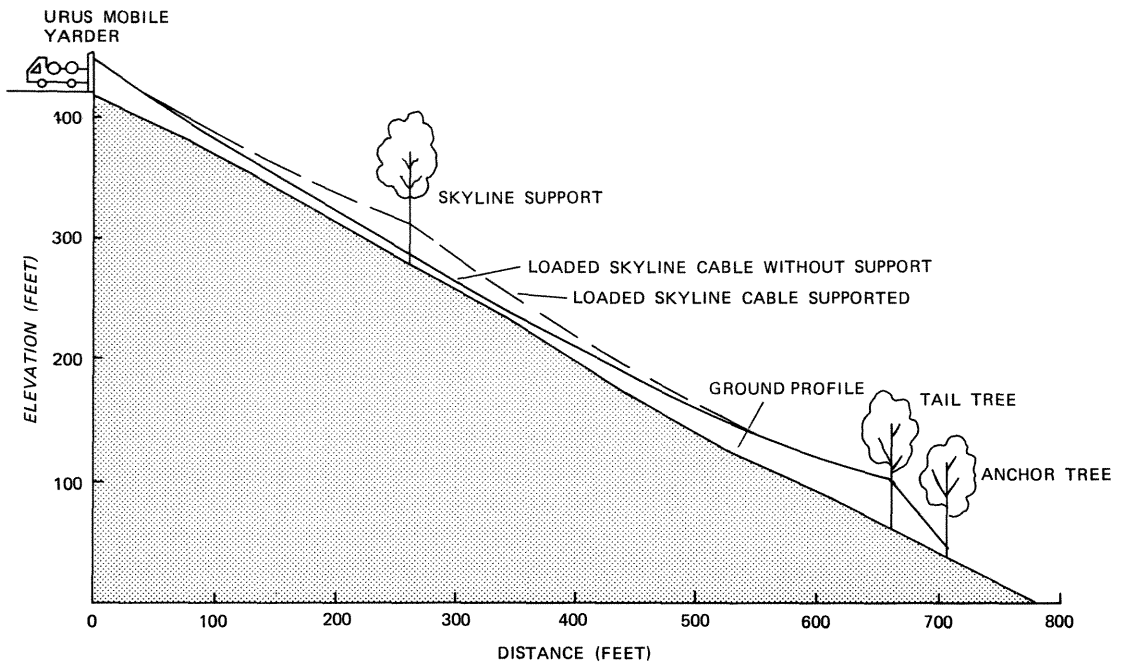
We have found that ground profiles of corridors can be made with a staff compass, 100-foot tape, and a surveying altimeter. An Abney level or clinometer can also be used to determine differences in elevation along the corridor. Field work is best done in the fall and winter when hardwoods have shed their leaves.

Suitable tail trees will seldom be found in line with the initial corridor centerline. If reference stations have been established on the original line, adjustments to the true line can be made by simple offset procedures. When adjustment of the original line is not necessary, the tail tree on the next corridor can be selected and the corridor centerline can be staked out going uphill. Frequently, however, rock outcrops or poor machine sites will require that this line also be adjusted. To complete the job, a stake is set to mark the location of the tower, the corridor centerline is flagged, and the tail tree and skyline anchor trees are flagged. When guylines are needed on the tail tree, guy trees are also flagged.

From the field survey notes the loaded skyline profile can be plotted over the ground profile by one of the available computer programs (Carson and others 1971). This plotting will indicate whether topography is a problem by showing the critical points along the loaded line, and where and how much the skyline must be elevated for logs to clear ground obstructions adequately (Fig. 3). If problems appear, the options previously mentioned can be used to overcome them.

In partially-cut stands, we observed that yarding hangups were less frequent when corridors were oriented at right angles to the contour. At less than right angles, logs on the uphill side of the skyline tend to roll behind trees and rocks when being yarded to the skyline. In clearcut areas, orientation of skyline corridors is less critical.

Figure 3.—Typical skyline profile on a relatively uniform slope.



Intermediate Supports

Although our tests with the URUS were not designed to study intermediate supports per se, we used them frequently and have a good idea of what they involve.

Intermediate supports add to the work of planning, laying out, and rigging for a skyline operation. The added work is about the same in clearcuts as in partial cuts. In both, corridor locations must be selected and support trees designated before cutting, because suitable support trees at the critical deflection points might otherwise be cut. When choice must be made, it is better to locate trees uphill from critical points. In rigging support trees, the blocks are normally hung about 25 to 30 feet high to obtain a clearance of 4 to 6 feet between the skyline and the ground when the skyline is loaded to capacity.

Only skyline systems that can be rigged as standing or fixed skylines can be used with intermediate supports. To our knowledge, supports have not been used with running skylines.

In planning a skyline cable operation where to-

pography presents serious deflection problems, we have to consider whether the increase in skyline length obtainable by using intermediate supports can be justified. The major disadvantage of shortening corridor length, from 800 feet to 500 feet, is the increase in road density required to log a given area. It also reduces by about one-third the area logged per corridor. Where deflection permits longer spans to be efficiently logged without intermediate supports, costs can be spread advantageously over larger volumes. For example, the additional time needed to pull out an additional 500 feet of skyline is small compared to the increase in volume that might be obtained. If increasing span length means using one or more intermediate supports, then the additional work required to set them must be carefully evaluated. In addition to rigging time, the time in planning, skyline layout, location of critical points, and selection and designation of support trees must be included. Where environmental constraints severely limit road construction, long multispan skylines may be the only way timber can be harvested.

Timber Felling

Timber felling is most important for efficient skyline logging in partial cuts, less critical in clear-cuts. Trees felled haphazardly or crisscrossed will hang up and slow the yarding operation when they are pulled toward the skyline. Whenever possible, trees should be felled downhill, at an angle of 25 or 30 degrees from the skyline corridor. This herringbone pattern is particularly important in partial cuts. In this position, logs are pulled more easily toward the skyline, with less side-strain on the system than if they are at greater angles. Usually, the higher the skyline (i.e. the greater the clearance between ground and skyline), the less critical timber felling becomes. With a high skyline, the hooked end of the log is raised above the ground sooner in lateral yarding, and the likelihood of its hanging up is reduced.

Choker Setting

In skyline logging where partial cutting is used, choker setting is probably the most important job. The choker setter must stop the carriage at a point on the skyline where logs hooked to it can move unobstructed toward the skyline, and cause a minimum of residual stand damage and site disturbance. Good communication must be maintained between the choker setters and yarder operator. After some experimentation, we found that portable remote control systems such as the Talkie-Tooter² worked well.

At first we used conventional cable chokers, but often they were too long and the front end of the log was not lifted above the ground. Then we tried chokers of various sizes, taking a couple of hitches around small logs, but it was always a problem to free the logs from obstacles and unhook. We finally settled on chain chokers which enabled us to hook the mainline within 3 or 4 inches of the log. These worked well except that yarding was usually limited to one log. Where clearance between the skyline and ground is a problem, 2 or 3 more feet of lift on the front end of the log can eliminate many hangups during yarding.

Skyline Rigging

Rigging a standing skyline such as the URUS consists of guying the tower, hanging a block in the tailtree, guying the tailtree (if necessary), and tying the skyline to an anchor tree or stump. If intermediate supports are required, the rigging in-

cludes a block in each of two trees (one on each side of the skyline), guying these trees, hoisting the intermediate supports with a portable winch, and tying-off the support cable (Fig. 3). Intermediate supports should hold the skyline at least 15 feet above the ground.

Another problem in rigging is to find suitable tail and support trees; usually over 14 inches dbh, well-anchored, and with no visible rot in the stem or upper bole. They must have 20 to 30 feet of clear stem and be climbable with tree spurs or a ladder. Ideally, intermediate support trees should be 20 to 30 feet apart, and on about the same contour level. Guy trees can be somewhat smaller, probably not less than 12 inches at the stump, where most guylines will be tied off. Otherwise, these trees should possess the same characteristics as tail and support trees.

In the URUS tests, we hung the tail block about 30 feet above the ground. Tree climbing ladders worked best for our crew but we see no reason why climbing spurs cannot be used. Ladders are cumbersome to move from one corridor to another, especially across cut-over areas.

Cable logging requires a high degree of practical engineering know-how and skill; people with this ability are needed to make systems such as the URUS workable. Shorter skyline spans (500 feet maximum) and machines with spars of 40 feet or more can simplify the rigging job by eliminating intermediate supports. Also, cable logging probably is more strenuous than conventional logging because heavy loads often must be carried down steep slopes for 600 to 800 feet. There is no dense road system, as there is in conventional logging, to walk or drive on. Rigging would be easier if roads were spaced to give access to tailtrees or perhaps even allow the use of mobile tail spars.

Some Thoughts on a Skyline System for the East

Two years' experience with the URUS and observation of other cable systems in the eastern and western United States provides us some insight as to the kind of machine best suited for the Appalachian mountains. Because eastern ownerships are small, and rights-of-way are often difficult to obtain, the machine should be highly mobile and able to negotiate steep, narrow roads (12 to 14 feet wide). If the machine is mounted on rubber tires rather than tracks, short moves over public roads can be made without loading it on a lowboy.

The size of the machine is another important consideration. Many bridges in the East have weight limitations, so the machine weight should not exceed 70,000 pounds. The cost of a machine, of course, varies with its size, but we believe that the cost will have to be less than \$100,000 if the average eastern contract logger is expected to purchase one.

The machine should have a swinging boom so that logs can be decked parallel to the road or dropped in the road behind the yarder. This is safer for the crew and logs can be cold-decked, if necessary.

Since setup and tear-down times are important components of cost, we believe the machine should be equipped with hydraulic guyline winches and hydraulic outriggers for leveling. In addition, the machine should have a mainline speed of 1,000 feet per minute and be operable with four men or less.

In the West, the least volume removed in thin-

nings was about 6 M bm/acre. The stumpage value of this material is similar to our hardwood values. Most eastern hardwood stands are harvested using some partial cutting system, and usually they will only support a cut of about 4 to 6 M bm/acre every 20 to 30 years. If skyline cable logging is feasible under these conditions, we feel that some of the machines used in the West for thinning (Fig. 4) might be of suitable size and cost for logging in the East.

The machines used for thinning small material (10 to 20 inches dbh) in the West are much larger than we had envisioned. Even though most material logged in the East is in this size range, hardwoods weigh about one-third more per cubic foot than western conifers. We feel that a machine should be rugged and capable of yarding a 10,000 pound load. Failures in our system always occurred when hangups caused maximum loads on the system.

In our opinion, a running or live skyline system

Figure 4.—A converted shovel at work in the western United States.



would best suit our needs—a machine capable of lowering or raising the skyline at will. These systems permit the use of simple, more rugged carriages. Carriages that lock automatically require more care and adjustment, and are less able to withstand day-to-day hard use. Simple, rugged slack-pulling carriages that can yard logs laterally from 100 feet on either side of the skyline are necessary for partial cutting. Running skyline systems usually have slack-pulling devices; the simpler systems, such as the live or shotgun, employ simpler carriages with manual slack pulling. Running skylines are the most versatile systems known today (Lysons and Twito 1973; Burke 1975), but we feel that cost of the available ones is prohibitive for most eastern operations.

The equipment should have the capability to yard from distances of at least 1,000 feet. Even though we visualize most spans in the 400- to 600-foot range, there are situations, such as across hollows or concave slopes, where the longer capability would be desirable.

Another feature to consider is the equipment's ability to log downhill. Theoretically, if you could log 500 feet uphill and 500 feet downhill, roads could be spaced 1,000 feet apart. However, downhill yarding has not gained wide acceptance. Most experienced loggers feel that its problems (for example, controlling the turn of logs and keeping them from rolling behind trees) were too great to overcome. It would be dangerous and impractical on midslope roads because it would require yarding over cut banks, and logs would be likely to roll. A running skyline system is probably best for downhill yarding, but yarders that have this capability are more complex and costly than systems that use gravity-powered carriages.

In summary, the combinations of timber volume and value in the East probably will not support the more sophisticated yarding systems used in the West. Until more suitable equipment is developed, a live skyline system with skyline and mainline drums and a gravity carriage seems most acceptable. It should be highly mobile and capable of yarding up to 1,000 feet. It should have a mainline speed of about 1,000 feet per minute and should be operable by a 4-man crew. It should have hydraulic guy winches, hydraulic outriggers for leveling, and a 40- to 45-foot "swing boom" tower. Even with these desirable features, it remains to be proven that skyline systems are an

economically viable alternative to existing ground skidding systems in the East.

Glossary

(Cable Logging)³

Carriage.—A wheeled device that rides back and forth on the skyline for yarding or loading.

Choker.—A noose of wire rope or chain for hauling a log.

Cold-deck.—An area where yarded or skidded logs are stored prior to hauling to the mill.

Corridor.—The path cleared to allow passage of the carriage and logs when yarding in partial cuts or thinnings.

Corridor length.—The cleared corridor distance between the tower and tailtree or skyline anchor.

Deflection.—The vertical distance between the chord and the skyline, measured at midspan—frequently expressed as a percentage of the horizontal span length.

Gravity feed.—Skyline system which depends on gravity to pull the carriage down the skyline.

Ground skidding.—Movement of the log from the stump to landing with a wheeled or tracked machine.

Guy.—A rope, chain, or rod attached to something to brace, steady, or guide it.

Guy tree.—A tree used to anchor a guy.

High-lead.—A cable logging system in which lead blocks are hung on a spar to provide lift to the front end of the logs.

Intermediate support or skyline jack.—A device that supports the skyline at an intermediate point.

Intermediate support tree.—Tree(s) located between the tower and tailtree to support an intermediate support or skyline jack.

Jammer.—A light weight, two-drum yarder, usually mounted on a truck with a spar or boom—may be used for both yarding and loading.

Live skyline.—A standing skyline that can be raised and lowered during yarding.

Main line.—The hauling cable.

Multispan skyline.—A skyline having one or more intermediate supports.

Rigging.—The cables, blocks, and other equipment used in yarding logs.

Running skyline.—A system of two or more suspended moving lines, generally referred to as main and haul-back, that when properly tensioned will provide lift and travel to the load carrier.

Skyline.—A cableway stretched tautly between two spars and used as a track for log carriers.

Skyline anchor.—Usually a tree or stump located behind the tailtree, when one is used to anchor the skyline.

³ Adapted from Glossary of cable logging terms, U.S. Dept. Agric. For. Serv. Pac. Northwest. For. Range Exp. Stn. Portland, Ore. (1969), and Cable logging systems (Studier and Binkley 1974).

Skyline block.—A block on the tailtree that the skyline runs through.

Skyline length.—The amount of line suspended between the headspar and skyline anchor.

Skyline logging.—A logging method in which a block or carriage rides on a skyline.

Span.—The horizontal distance between the headspar or anchor point, and the tail spar or anchor point.

Spar.—The tree or mast on which rigging is hung for one of the many cable hauling systems.

Standing skyline.—A skyline anchored at both ends.

Straw line.—A light cable used to string heavier lines.

Straw drum.—A small drum on yarders; handles the straw line.

Tailtree.A spar at the outer end of the skyline logging operation, away from the landing.

Tower.—A steel spar attached to the yarder used to support the skyline and other rigging.

Yarder.—A system of power-operated winches used to haul logs from a stump to a landing.

Yarding.—The act or process of conveying logs to a landing. In our opinion, it is more consistent with accepted terminology to restrict the term “yarding” to the conveying of logs with cable systems. “Skidding” refers to dragging logs behind animals or machines traveling on the ground.

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