STREAM PROTECTION WITH SMALL CABLE YARDING SYSTEMS

by

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ABSTRACT

Small cable yarder systems that can be purchased and operated by independent logging contractors have less potential negative impact on water quality than ground-based systems operating on steep terrain because they do not require such an intense road system. Stream protection costs were estimated at $3.78 per lineal foot of stream when a typical small yarder (Koller K-300) operated in a hypothetical cove hardwood stand.

INTRODUCTION

Cable yarding is being used again in the Eastern United States after an absence of approximately 50 years. Much of the steep terrain that was harvested around the turn of the century was harvested with cable yarding systems. They required more rigging and more manpower than modern cable yarding systems, but they did employ cable as the primary means of transport from stump to landing, as today's systems do. Most of these operations ceased by 1920, when most of the timberland had been cut over and burned. In the early 1970's, to overcome the problems of environmental damage and low production associated with conventional harvesting on steep terrain, cable systems were reintroduced in the Eastern United States.

One of the major pioneers in this area was Westvāco Corp., who used the Washington 78 Skylok [1/], a running skyline yarder, near Rupert, West Virginia. It would be classed as a medium-size yarder on the West Coast, but would be considered large for East Coast conditions. The yarding costs with the Washington 78 were high, but it was capable of high production during inclement weather when wood supplies could become critically low at the mill.

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Recent efforts have concentrated on small cable yarders that could be purchased and operated by independent logging contractors. Some small cable yarders on the East Coast are the Appalachian Thinner, Koller K-300, Smith-Timbermaster, Clearwater, Christy, and Bitterroot Miniyarder. A cable yarder will be defined as small if it has a tower less than 50 feet high, weighs less than 50,000 pounds, and costs less than $100,000.

SMALL CABLE YARDING SYSTEMS

The rigging configurations that have been used on cable logging systems in the United States have been described by Studier and Binkley (1974). Falk (1980) has described the major cable yarding configurations that are especially suitable for eastern logging, the operating characteristics of each, the commonly used carriages, and the major advantages and disadvantages of each system. Hawkes (1979) describes more than 40 cable harvesting systems for small timber, and gives the addresses of manufacturers and distributors. A summary of cable yarding field trials in eastern hardwoods is presented by Fisher and Peters (1982). Cable yarder systems are categorized by the number of winch drums on the yarder; they are:

Single-drum yarders. A typical system is shown in figure 1. The Appalachian Thinner, shovel loaders, and truck mounted cranes are examples of this system. Yarding is done uphill. Tongs are frequently used because they can be hooked and unhooked quickly and experience fewer hangups during inhaul, especially in partial cuts. The system provides little lift to the front end of the log (also called ground lead), so there will be some soil disturbance in the main skid path. Single drum yarders have maximum yarding distances of approximately 400 feet.

Two-drum yarders. Common systems are the highlead, live skyline, and multispan skyline. In the highlead system, figure 2, the mainline yards logs to the landing and the haulback line returns the rigging and chokers to the woods. Highlead systems can yard uphill and downhill.

In the live skyline, figure 3, the skyline can be slackened or tightened as required during the yarding cycle. Yarding is done uphill. The carriage returns to the woods by gravity when the mainline is slackened. When the carriage reaches the desired position on the skyline, it clamps to the skyline (or engages a stop) and releases the mainline, which pays out through the carriage. The mainline is attached to the logs and reeled in. When the end of the mainline reaches the carriage, the skyline clamp is released and the carriage and logs are pulled to the landing. The skyline often provides sufficient lift to raise the front end of the log off the ground during inhaul.

In the multispan skyline system, figure 4, the skyline is supported at intermediate points along its length by double-tree intermediate supports. In other respects, the multispan skyline is similar to the live skyline.

The maximum yarding distance for a small cable yarder system rigged as a highlead is 400 feet. The maximum yarding distance for the live skyline, or the maximum yarding distance between supports for the multispan skyline on a constant slope or convex profile, is also 400 feet. The maximum yarding distance of a skyline system on a concave profile depends on the production required.

Three-drum yarder. Common systems are the running skyline and the live skyline with haulback.

In the running skyline, figure 5, the skyline passes around a sheave fastened to a tailtree or tailhold stump and deadends on the carriage. Therefore the skyline also serves as the haulback. The other two lines are the mainline and the slackpulling line. The running skyline can yard uphill and downhill, and works well in partial cuts because the carriage can be positioned precisely with excellent control. However, very few commercially available running skyline yarders meet the definition of a small cable yarder.

The live skyline with haulback (not shown) can yard uphill and downhill. The time required to rig the system up and take it down often exceeds 4 hours, depending on yarding distance and terrain, which limits its range of economic application.

CABLE APPLICATION ON STEEP TERRAIN

Ground vehicle logging systems require a dense network of skidroads (typically 1 mile per 20 acres) as the terrain gets steeper. Somewhere in the neighborhood of 40 percent and greater slope, cable yarding systems are expected to be cost competitive with ground vehicle systems. The slope at which cable yarding would have the advantage is dependent on the road costs, timber size, volume per acre, terrain, equipment employed, environment protection costs, etc.

In the near term, small cable yarding systems will be used mainly for yarding uphill. The principal reason is that uphill yarding systems are much easier and faster to rig. The most common timber harvest unit layouts are parallel or fan-shaped, figure 6. Parallel corridors, perpendicular to the contours, are common when there is a prominent ridgeline, as there is in the ridge and valley sections of Pennsylvania. Parallel corridors are often used in partial cuts. Fan-shaped units are often located on secondary ridges. In broken terrain, a single span may be able to reach from one ridge to the next, resulting in a harvest unit with excellent deflection and payload capability. Payload capability can be predicted and is a very important element in harvest unit planning. Techniques are available to calculate payload capability by hand (Binkley and Sessions, 1978), by handheld calculator (Falk, 1981) and by minicomputer (Nickerson, 1980).

WATER QUALITY EFFECTS

The principal impact on water quality from timber harvesting is sediment in the streams. Most of the sediment produced comes from mineral soil exposed in harvest-area truck roads, skidroads, and landings. Any harvesting system that reduces the road density also reduces the potential for environmental impact.

Kochenderfer (1977) found that on steep slopes in the Central Appalachians, road densities were 1 mile per 19.8 acres for areas harvested with a wheeled skidder and 1 mile per 31.1 acres for areas harvested by jammer (truck-mounted crane), table 1. For a small cable yarder with a 400-foot reach, road densities required would be 1 mile per 48.5 acres. Cable yarding systems have less potential environmental impact through sediment production because they require less road mileage. Also, the roads for cable yarding systems are normally located farther from the streams, so there is a greater opportunity for the sediment to be captured before it reaches the stream (Megahan and Schweithelm, 1983).

Table 1. Exposed mineral soil in harvest area truck roads, skidroads, and landings, by harvest system.

Yarder	% of area with mineral soil	Acres per mile of road	Road width (feet)	Reach (feet)
Wheeled skidder	10.3	19.8	16.8	163
Jammer	7.8	31.1	20.0	256
Urus (large) skyline	2.3	105.4	20.0	869
Small skyline	5.0	48.5	20.0	400

Sources: Kochenderfer 1977, Patric and Gorman 1978, computed.

Another potential adverse impact on water quality is associated with the felling operation. Treetops left in the stream could potentially block the stream and temporarily reduce oxygen in the stream to undesirably low levels (Brown, 1980). This potential impact is not unique to cable yarding and is best controlled by directionally felling the trees away from the stream or by leaving a buffer zone of unfelled trees.

THE COST OF STREAM PROTECTION

The implied cost of stream protection will be illustrated by an example. A hypothetical harvest area of 20.66 acres (500 x 1800 feet) which includes a perennial stream will be harvested by one of three options:

(1) Option 1 affords maximum protection to the stream by establishing a buffer zone of 100 feet on either side of the stream,

(2) Option 2 affords minimum protection to the stream because trees are felled, limbed, topped and yarded tree length. Trees on the far side of the stream are dragged through the stream during yarding,

(3) Option 3 affords some protection to the stream because trees on the far side of the stream are bucked to maximum lengths of 24 feet, so turns of logs can be fully suspended when yarded across the stream.

The harvesting options are illustrated in figure 7.

The stand is a cove hardwood stand whose major components are hard maple, red oak, basswood, yellow poplar and beech. The harvest prescription is clearcut. The average diameter at breast height is 12.7 inches; trees of 5-inch dbh and above are included in the average. The stand contains 11.34 Mbf/acre of sawlogs and an additional 24 cords/acre of fuelwood; all from 148 trees per acre. The mill sawlog values are $250/Mbf, $200/Mbf, and $100/Mbf for Grade 1, 2, and 3 sawlogs, respectively. Fuelwood is valued at $20/cord at the landing. Sawlogs are 33 percent Grade 1, 26 percent Grade 2, and 41 percent Grade 3. Total product value or revenues are $2,470/acre.

The yarding production and cost were estimated from the performance characteristics of the Koller K-300 cable yarder (Rossie, 1983; Stuart and Rossie, 1984). The average cycle time, including delays, for the Koller K-300 is given by:

$$\bar{c} = 3.67 + 0.0052\,\bar{x} + 0.0114\,\bar{z}$$

where $\bar{c}$ = average cycle time, minutes
$\bar{x}$ = average slope yarding distance, feet
$\bar{z}$ = average lateral yarding distance, feet

Production rates and costs were estimated by a procedure similar to those presented by Peters (1984) and LeDoux [2]. The estimated yarding production and costs are presented in table 2.

Table 2. Effect of harvesting option on yarding production and costs; 4612 $ft.^3$ (148 trees) removed per acre.

Item	Option 1 (buffer)	Option 2 (drag)	Option 3 (fly)
Acres yarded	12.40	20.66	20.66
Maximum horizontal yarding distance, ft.	300	500	500
$Ft.^3$/piece removed	25.2	25.2	23.0
Pieces/acre	183	183	200
$Ft.^3$/turn	46.9	46.9	44.1
Cycle time, minutes	5.11	5.69	5.80
Production, $ft.^3$/day	3497	3322	3043
Cost, $\$/ft.^3$ [a]	0.160	0.169	0.184
Total cost	$9,150	$16,100	$17,530

a/ includes yarding, skyline corridor changes, and move in and out costs.

Parallel settings were used to harvest the area. Each unit or set was 200 feet wide by 500 feet long (Option 2 and 3) or 200 feet wide by 300 feet long (Option 1). The time required to change skyline corridors was 60 minutes. The time required to move harvesting equipment in and out of the area was 360 minutes. Mechanical downtime was estimated at 10 percent of the total scheduled time. Ground slope was 50 percent. A Prentice 210 loader was used at each landing to keep the landing clear. The cost for the Koller K-300 yarder, the Prentice 210 loader, and a five-person crew was $70/hour (Rossie, 1983).

2/ LeDoux, C. B. Stump to mill timber production cost equations for eastern hardwoods. Unpublished report on file at the Northeastern Forest Experiment Station, 180 Canfield Street, Morgantown, WV 26505.

The principal effects of the harvesting options on yarding production and cost are summarized in table 2. Option 1, with maximum environmental protection, had a 300-foot maximum yarding distance, production of 3,497 cubic feet per day, and unit yarding costs (including skyline corridor changes and move in and out) of $0.160 per cubic foot. Option 2, with minimum environmental protection, had a 500-foot maximum yarding distance, production of 3,322 cubic feet per day, and unit yarding costs of $0.169 per cubic foot. Option 2 cost more than Option 1 because yarding distance and cycle time were increased. Option 3 was similar to Option 2 except that trees on the far side of the stream were required to be fully suspended over the stream. This required that tree length stems be bucked to a maximum length of 24 feet which reduced the average volume per piece from 25.2 to 23.0 cubic feet, the average volume per turn from 46.9 to 44.1 cubic feet, and production from 3,322 to 3,043 cubic feet per day. Cost increased from $0.169 to $0.184 per cubic foot. The return to the landowner is also affected by the harvesting option chosen.

The net returns to the landowner from the potential harvest of 20.66 acres are $11,500, $18,310, and $16,570 for Options 1, 2, and 3, respectively, (Table 3). The difference between Option 1 and Option 2, $6,810, represents the cost of stream protection for the 20.66 acres. Since 1,800 feet of stream are contained in the unit, the implied cost of stream protection is $3.78 per foot of stream. Option 3 represents a compromise between minimum and maximum protection; in the example the landowner incurs a 9 percent reduction in returns by fully suspending the logs across the stream.

Table 3. Effect of harvesting option on return to the landowner; 4612 $ft.^3$ (148 trees) removed per acre.

	Option 1 (buffer)	Option 2 (drag)	Option 3 (fly)
Total revenues	$30,630	$51,030	$51,030
Less:			
Fell, buck, limb	2,010	3,340	3,650
Yarding	9,150	16,100	17,530
Loading	1,140	1,900	1,900
Hauling	6,830	11.380	11.380
Total costs	19.130	32,720	34,460
Net revenue	$11,500	$18,310	$16,570

CONCLUSIONS

1. Small cable yarders yarding uphill are the most probable near-term commercial application of cable yarding in the Northeastern United States.

2. Cable yarding can reduce environmental impact, when correctly employed, by minimizing the area disturbed in truck roads, skidroads, and landings.

3. The costs of stream protection can be estimated for a cable yarding system if the appropriate data from field tests of that system are available. For the example presented here, a Koller K-300 cable yarder operating in a cove hardwood stand which averaged 11,340 board feet per acre of sawlogs (¼-inch International Scale) and 24 cords per acre of fuelwood, a cost of $3.78 per lineal foot of stream protected was estimated.

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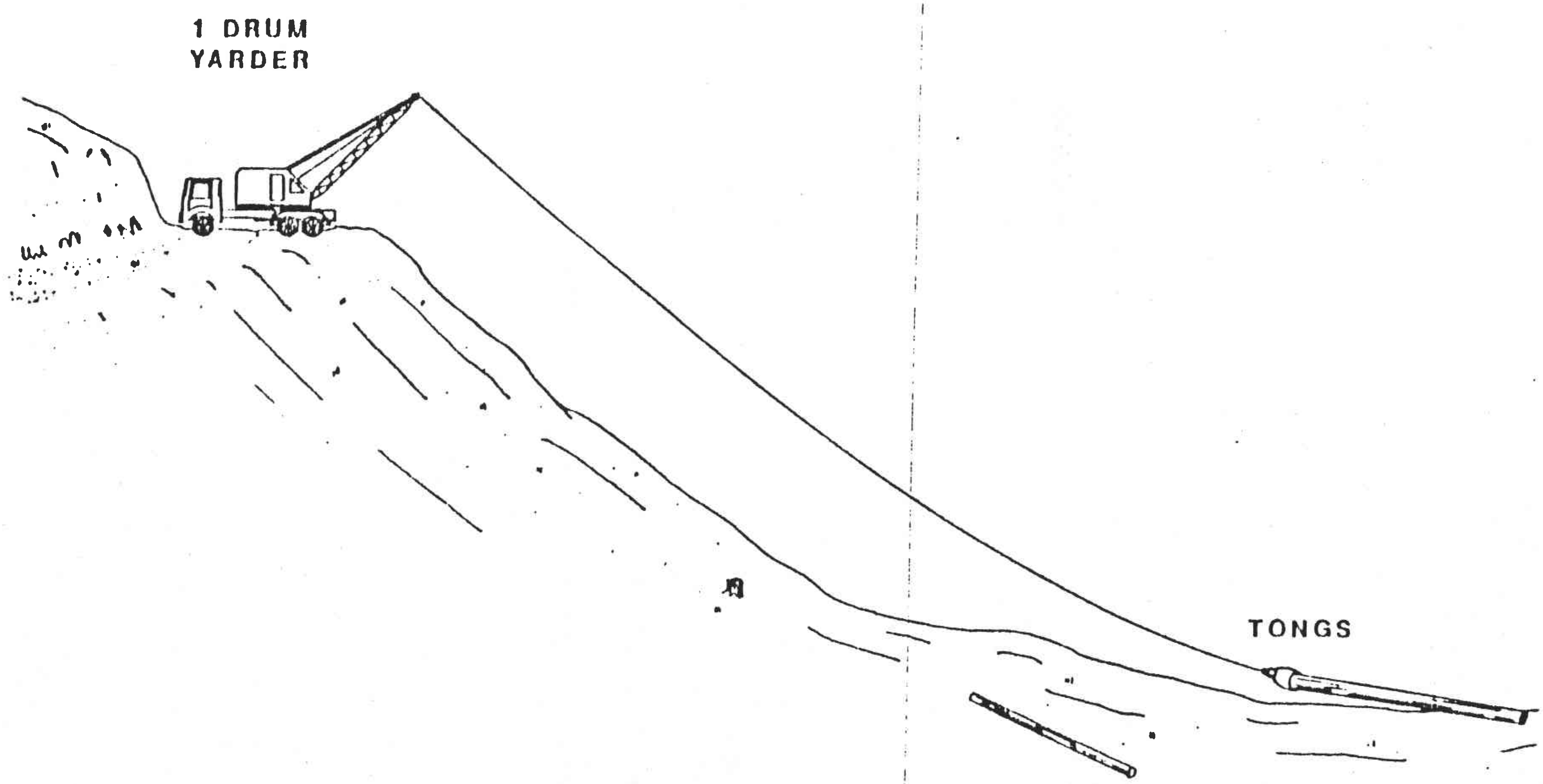

Figure 1 Single Drum Cable Yarding System

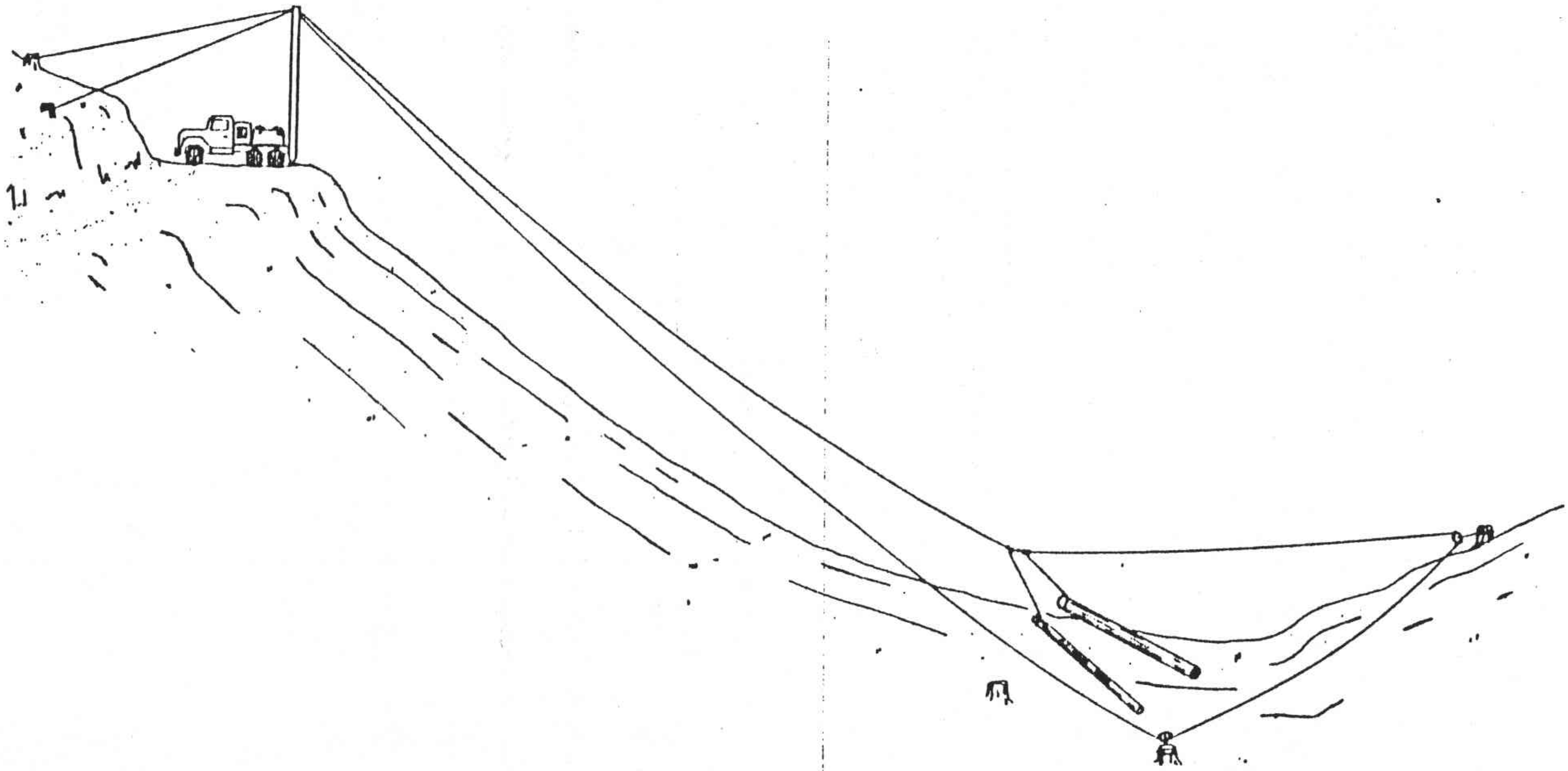

Figure 2 Highlead Yarding System

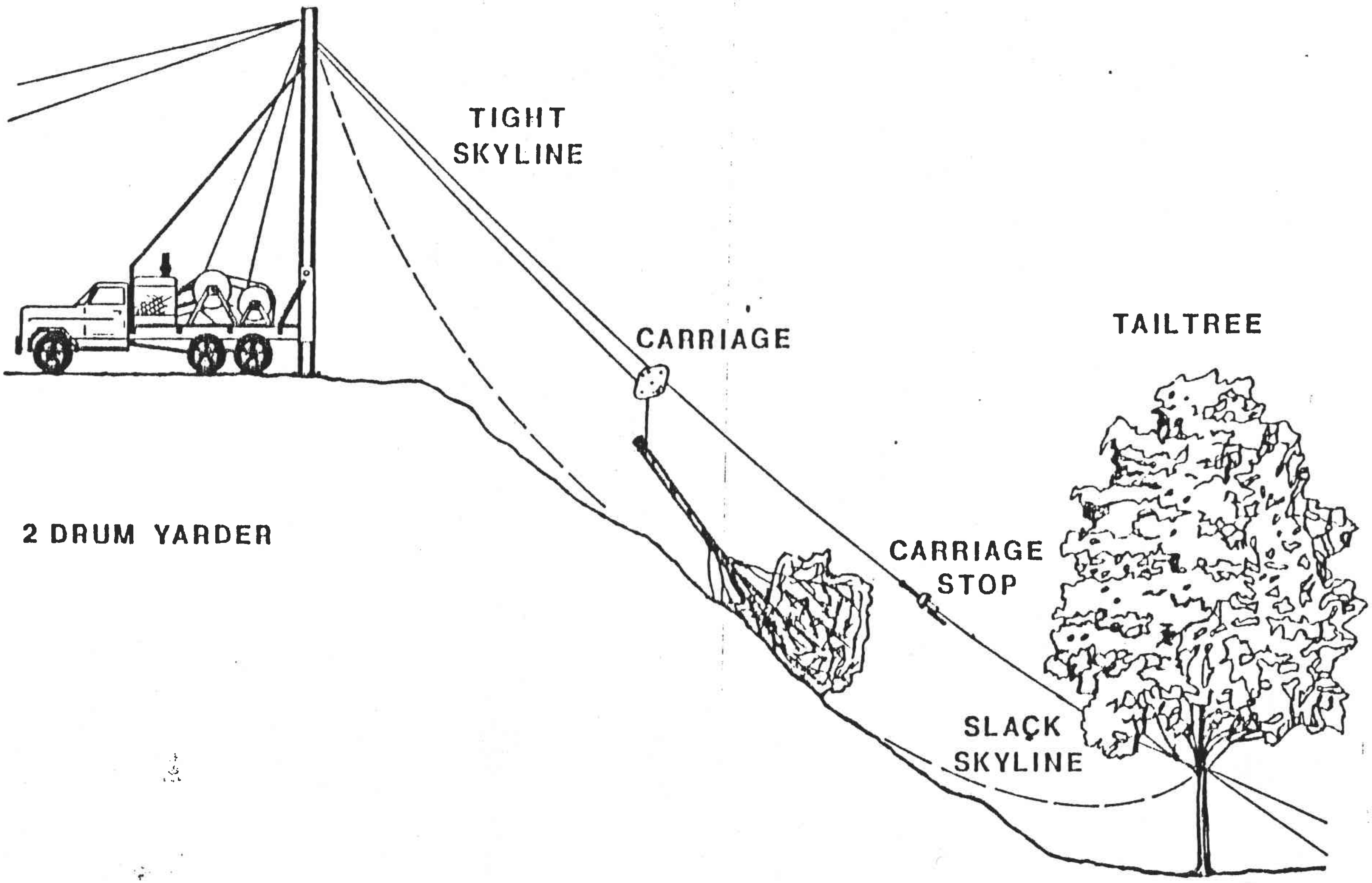

Figure 3 Live Skyline System

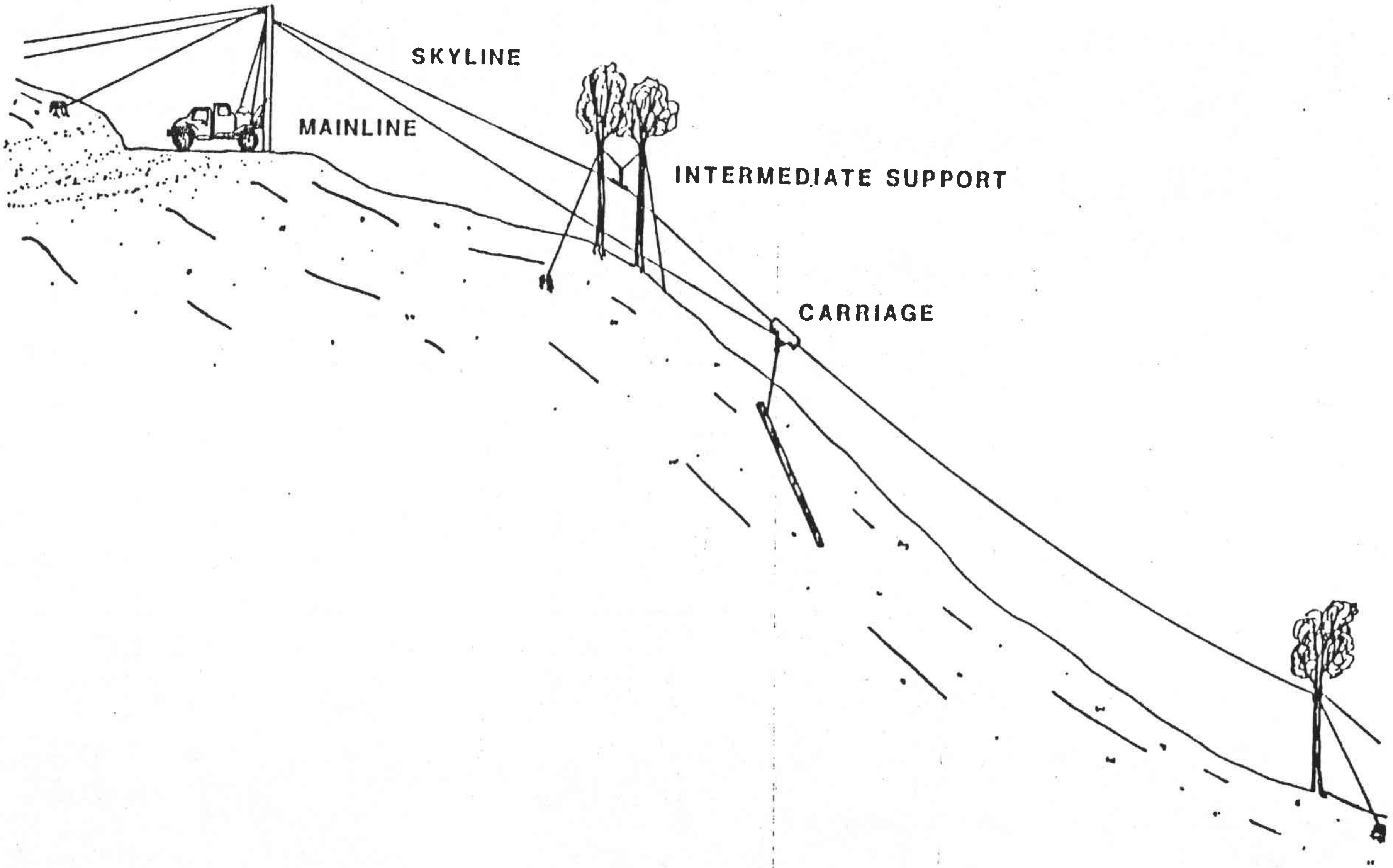

Figure 4 Multispan Skyline System

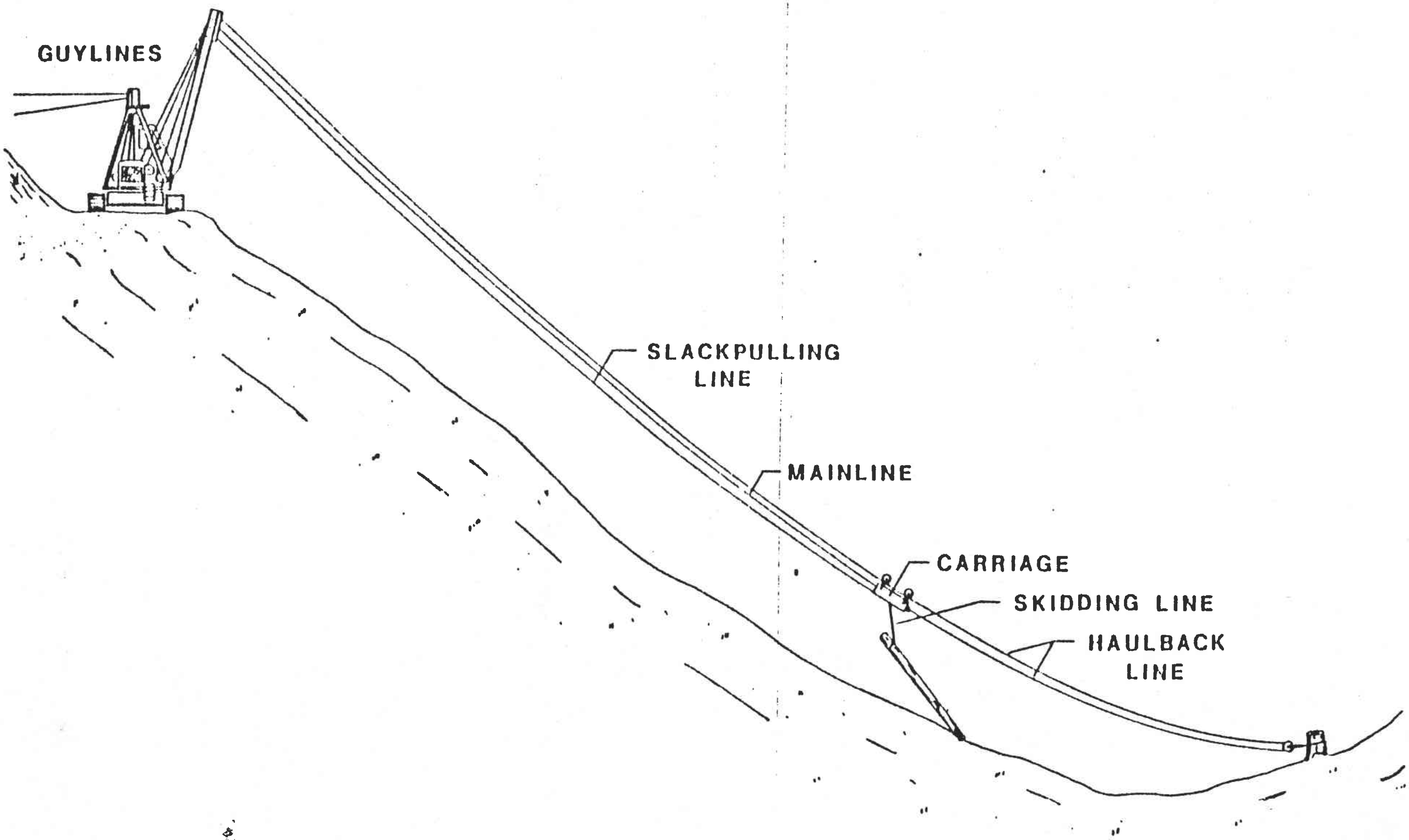

Figure 5 Running Skyline System

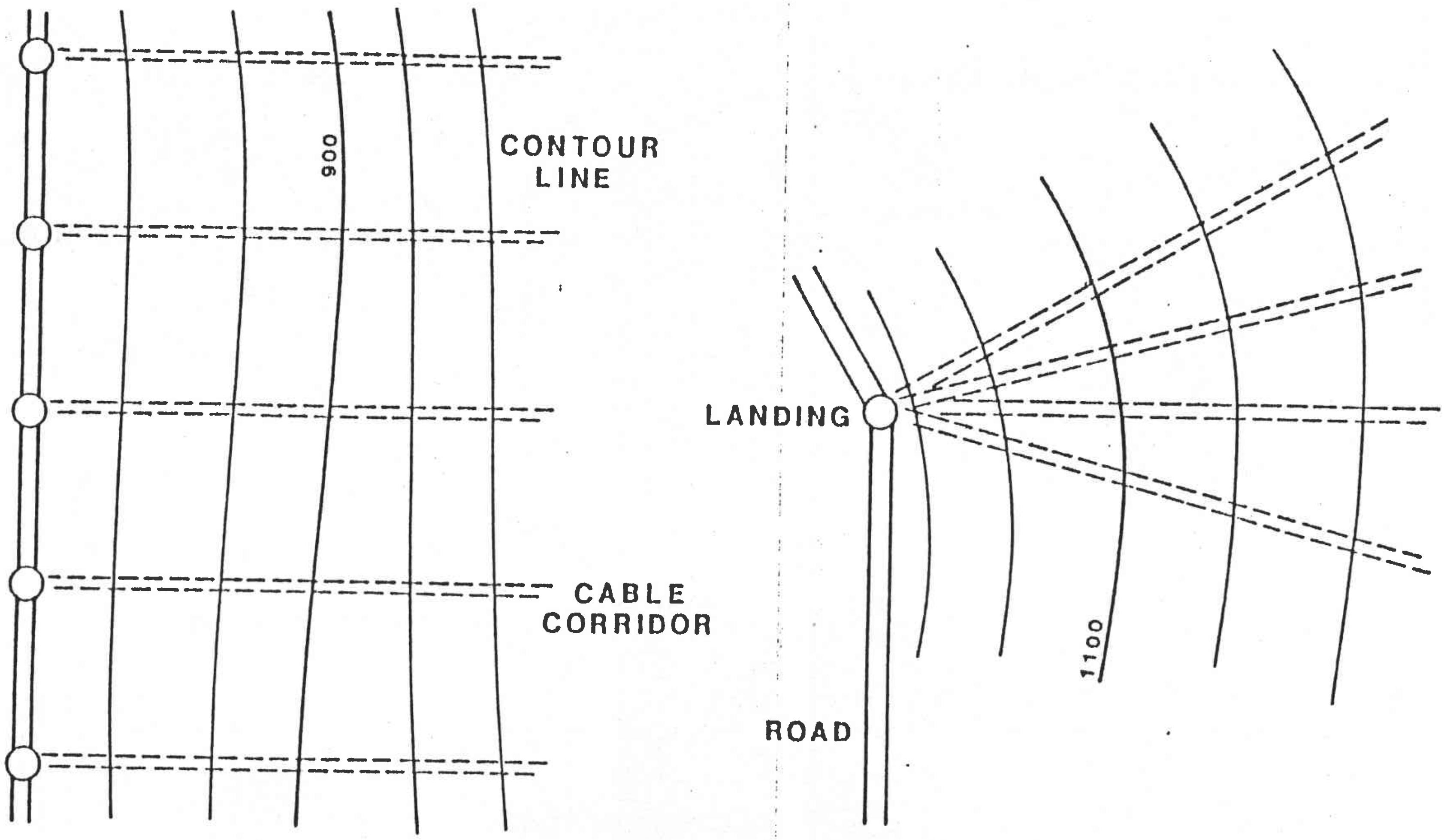

Figure 6 Typical Parallel and Fan Shaped Harvest Unit

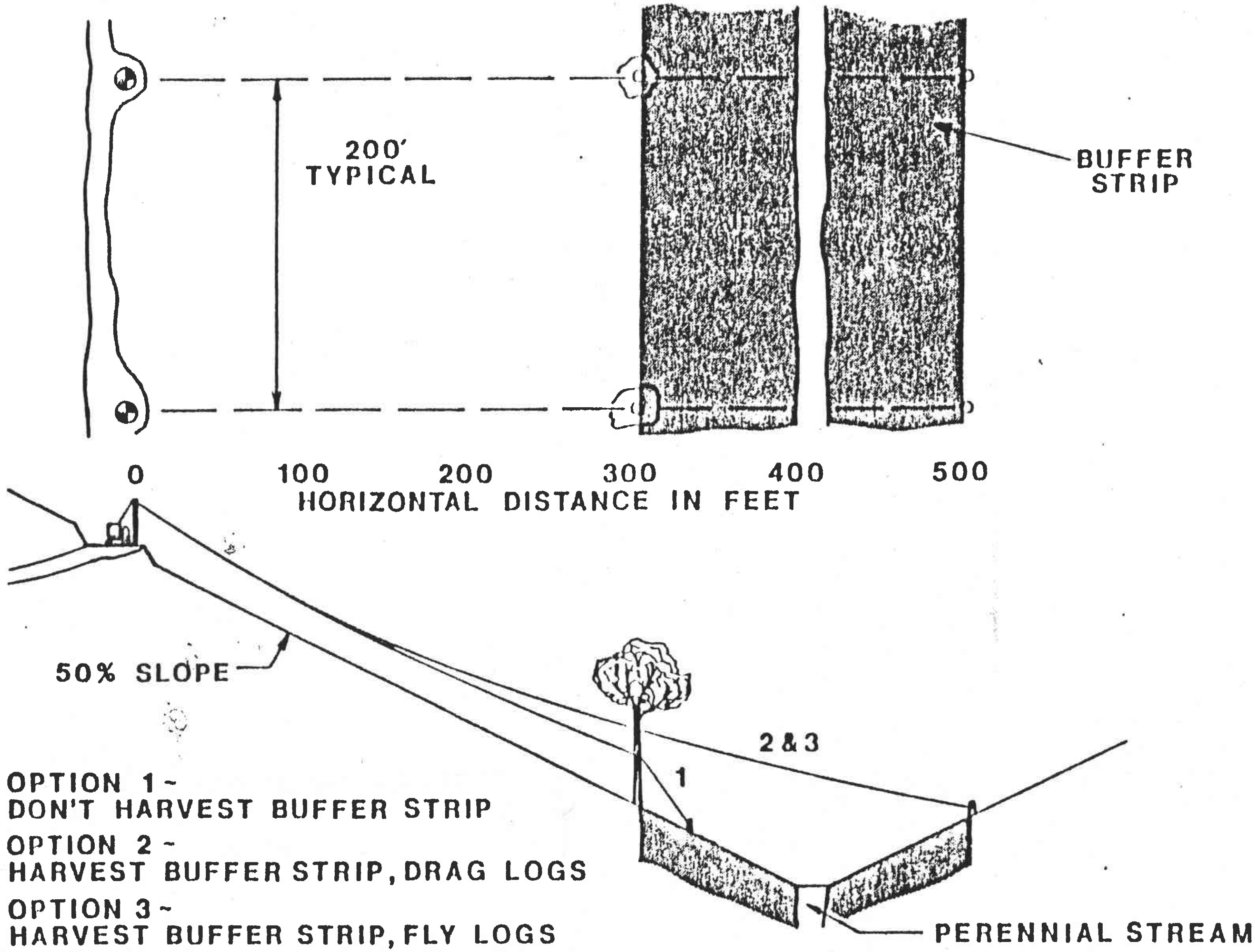

Figure 7 Three Harvesting Options Afford Different Levels of Stream Protection

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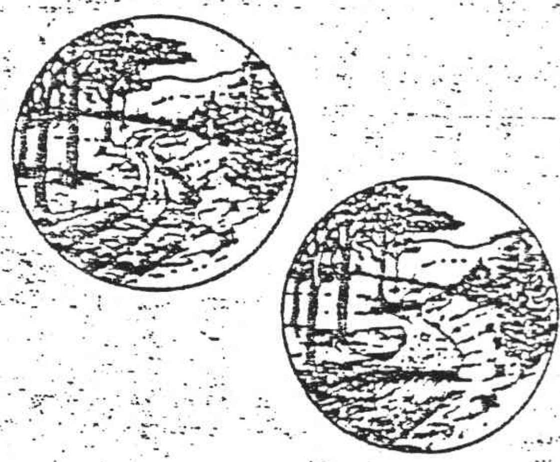

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