

# Harvest Operations



An easy way to loose money, if not planned properly even under the best of circumstances

# Overview

UW

- **Background-What's out there on the ground**
- **Basic harvest operations**
- **What systems do we have; a taxonomy**
- **A closer look at**
  - **Ground systems**
  - **Cable systems**
  - **Helicopters**
- **Logging Costs**
- **What's around the corner**

# Harvest and Supply Trends in Oregon

- **Annual Harvest:**
  - Historic high of 8.7 billion board feet in 1986
  - Decline of 42% to an average of 3.7 billion board feet
- **Productive forest land base: 22.6 million acres (56% under Federal ownership)**
- **A good portion of harvest operations will be partial cuts, rather than clear cuts**

# Every logging operation consists of the following 4 phases

UW

- **Felling** – The trees are cut down
  - **Yarding** – logs are moved from the stump to the landing
  - **Loading** – Logs are loaded for transport to the mill
  - **Haul** – Transport to the mill (usually by truck)
- \* **Processing** – trees are cut to useful lengths and limbs are removed
- \* **Bucking and limbing** occur at different stages in the first three steps, depending on the harvest system in use.

# Motor-manual felling and bucking/limbing of <sup>UW</sup> trees



**Poor bucking: loose ~40% in value**

# Mechanized Felling

- Carrier-based feller buncher
- FB cuts a swath, puts trees down into bunches



# Multi-Function machines - harvesters

## Harvester felling and processing trees



Mat of slash

# Stand density and tree size impact falling production and costs

UW

Factor	Motor-manual (Chainsaw)	Feller-buncher Boom type	Harvester
Timber size capability	All sizes, best for larger timber	< 60 – 70 cm	< 50 cm
Forwarding method	Skidder (wheeled or tracked) with winch	Skidder (wheeled or tracked) with grapple, clam bunk, Shovel	Forwarder
Limiting Slope %	Up to 35%, downhill preferred	Up to 35%, with self-leveling cab, up to 50%	Up to 50%
Product	Whole tree, or logs (> 8 m)	Whole tree	Short logs (< 8 m)
Equipment costs (\$)	300 - 700	280-320,000	300-400,000
Hourly owning & operating costs	55 – 58 \$/Hr	80 – 110 \$/Hr	100 – 120 \$/Hr

# Yarding (Primary Transport)

- **The process of moving the trees (or logs) from the stump to the road: yarding or primary transportation..**
- **A yarding cycle consists of traveling from the landing to the stump, grabbing a turn of logs, moving these back to the landing, and depositing them.**
- **Yarding cycle = outbound + pickup + inbound + drop + delay**
- **The economic and environmental costs of yarding are the sum of these component costs.**

# Yarding (Primary Transport) Systems

- **Ground-based yarding (e.g., skidders, forwarders, crawler tractors);**
- **Cable yarding (e.g., highlead, skyline);**
- **Aerial- helicopter yarding (commonly referred to as helicopter logging).**

# Ground-based forwarding (skidding)

GROUND-BASED			
<u>skidders</u>		<u>forwarders</u>	
rubber-tired	tracked	Rubber-tired (Scandinavian)	Tracked (Shovel/ excavator)

# Yarding (Primary Transport)

## Ground-based forwarding - Skidding

Rubber-tired skidder and a tracked skidder (crawler tractor, right) with grapple attachment to skid logs. Grapple size openings (cross sectional area) determine the number of logs that can be skidded



# Forwarder with 15 ton payload

- Moves slowly and travels on slash
- Bigger pay loads, fewer trips
- Slash gets mixed in with soil
- Reduced fire risk



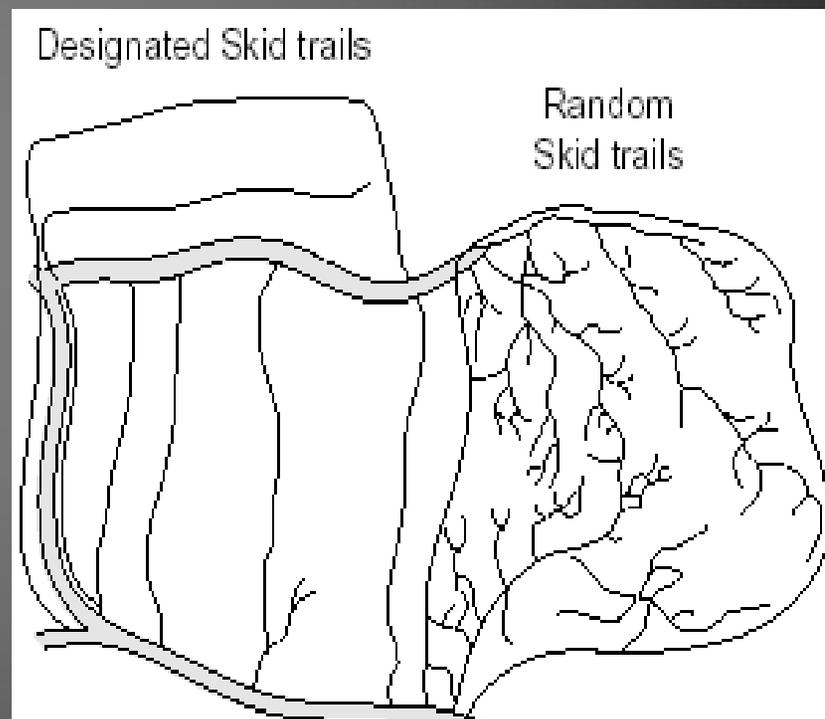
# Shovel yarding

- Shovel high-production forwarding
- Short yarding distances ~300 ft



# Pre-planned skid trails

- **Random skid trails result in higher ground disturbance**
- **Designated or pre-planned skid trails disturb less area**
- **In any retention silviculture, e.g. thinnings, only designated skid trails should be used**



**Payloads, skidding or forwarding speed in combination with hourly owning and operating costs determine the costs of logs delivered to the landing (dollars/volume)**

Factor	Wheeled Skidder	Crawler Tractor	Forwarder	Shovel
Felling methods	Manual or feller-buncher	Manual or feller-buncher	Harvester	Feller-buncher
Maximum yarding distance (m)	Uphill 100 m; downhill and flat 100–500 m	Uphill 120 m; downhill and flat 100–300 m	150–600 m	Uphill 20–70 m; downhill 20–120 m
Payload (tonnes)	34 - 6	4 - 7	8 - 15	
Equipment Costs US\$	150-160,000	200-210,000	260-320,000	280-310,000
Hourly owning & operating costs (US\$/HR)	55 - 58	60 - 65	70 - 90	120 - 130



# Use of Cable Systems

- **Have a higher cost per unit of removal (\$/mbf) compared to ground-based systems**
- **Requires knowledgeable operational planning**

# Cable-based forwarding (yarding)

CABLE					
Highlead			True skylines		
Running skyline			Live skyline		Standing skyline
tower	Swing yarder		tower	Swing yarder	
	Grapple yarder	Swing yarder			

# Cable Yarding Systems

- **Highlead**
  - Grabinsky - Running Skyline
- **True Skylines**
  - Live skyline
  - Standing skyline
    - Single span
    - Multi-span

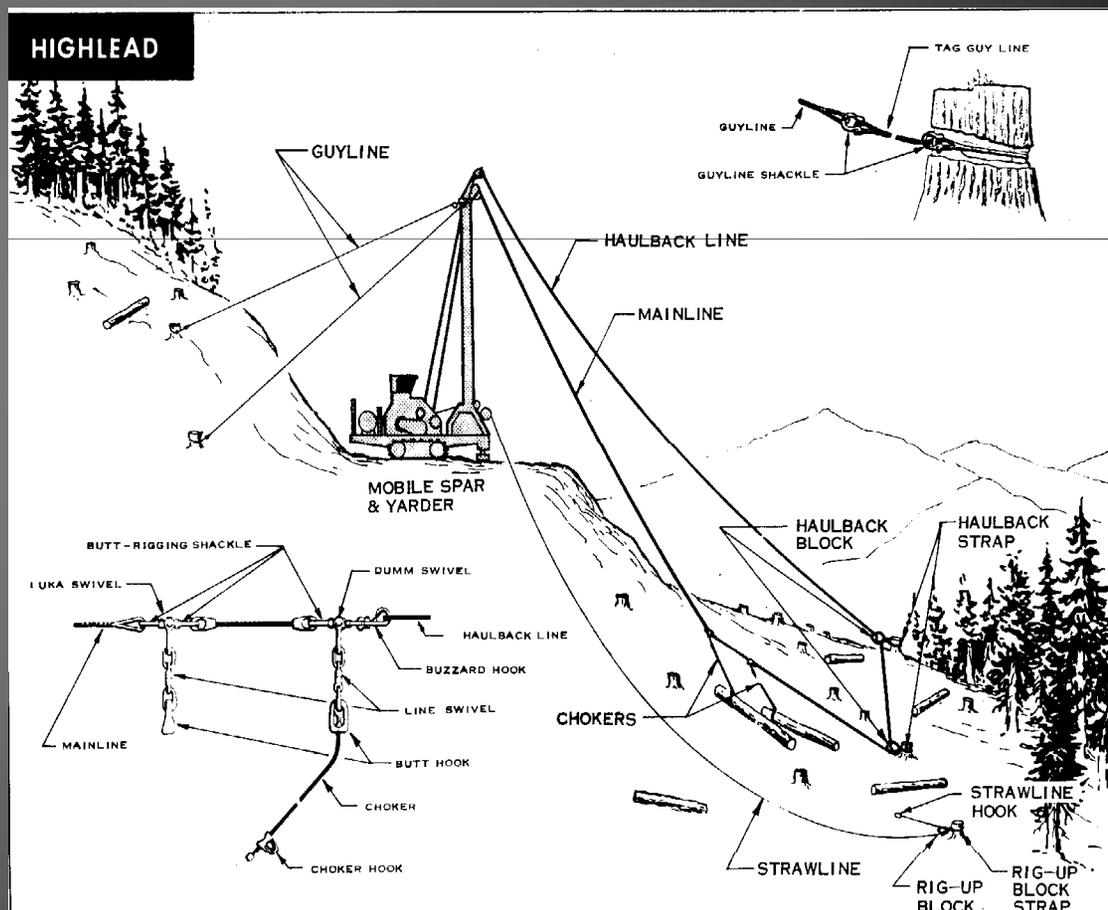


# Cable Yarding Systems

- **Highlead**
  - Logs are yarded with a cable and butt rigging, but are rarely suspended – ‘ground pounded’ to landing
  - Lower cost to rig up
  - Can have excessive soil disturbance, compaction
  - Clear cut system

# Highlead

- Simple; 2 drums
- Limited lift or suspension
- No lateral reach
- Max. yarding distance ~ 1000 ft
- Clear-cuts only



# Cable Yarding Systems

- **Skyline**
  - One-end to full suspension of turns/logs
  - **Live skyline** – skyline may be raised or lowered with inhaul of turn
  - **Standing skyline** – skyline is static throughout yarding cycle

# Cable Yarding Systems

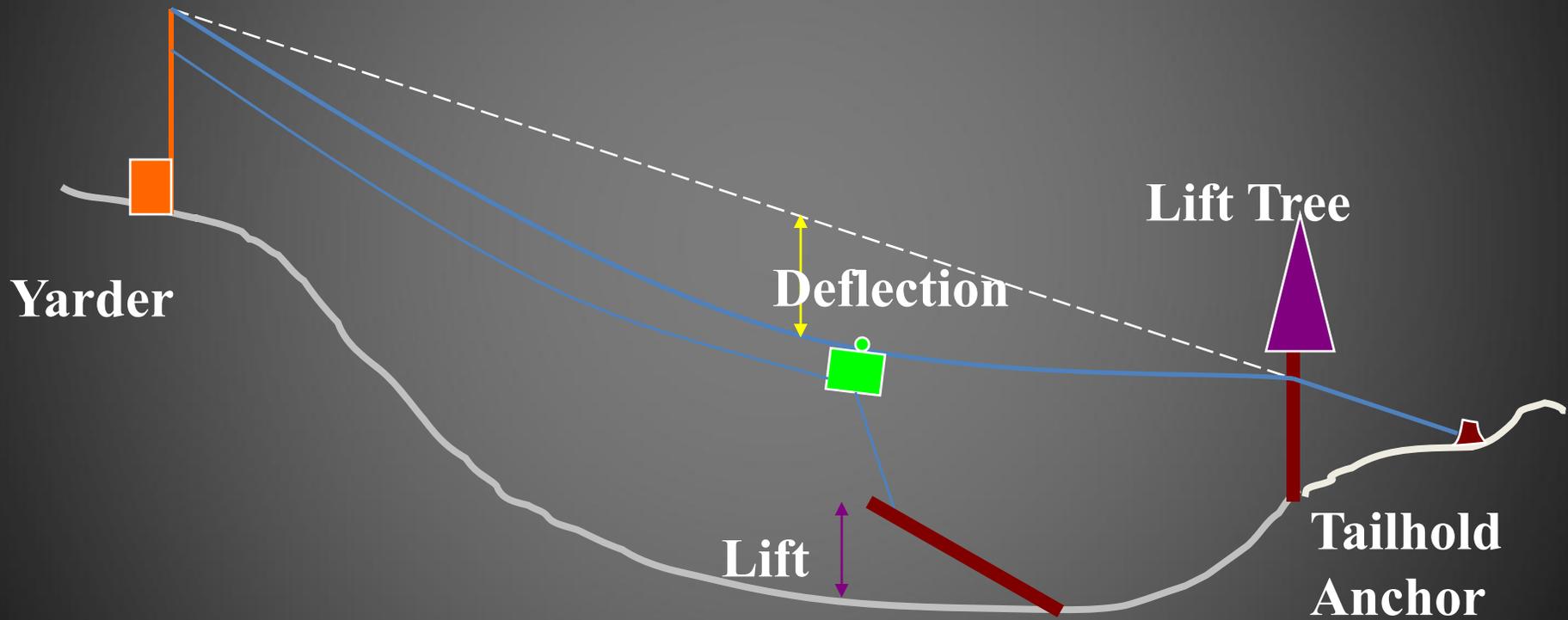
- **Skyline systems – what makes them work....**
  - **Lift – the clearance of the turn of logs over the ground as it is being yarded (drag or resistance is reduced)**
  - **Reduces site impacts by lifting the turn/logs over the ground and sensitive areas; increases yarding efficiency**

# Cable Yarding Systems

- **Skyline systems – what makes them work...**
  - **Deflection – the sag in the skyline from the ideal straight-line path between the tower and the lift tree (payload increases as deflection increases)**
    - **Long-span skylines ~ 10%**
    - **Multi-span ~ 2-5%**



# Deflection and Lift

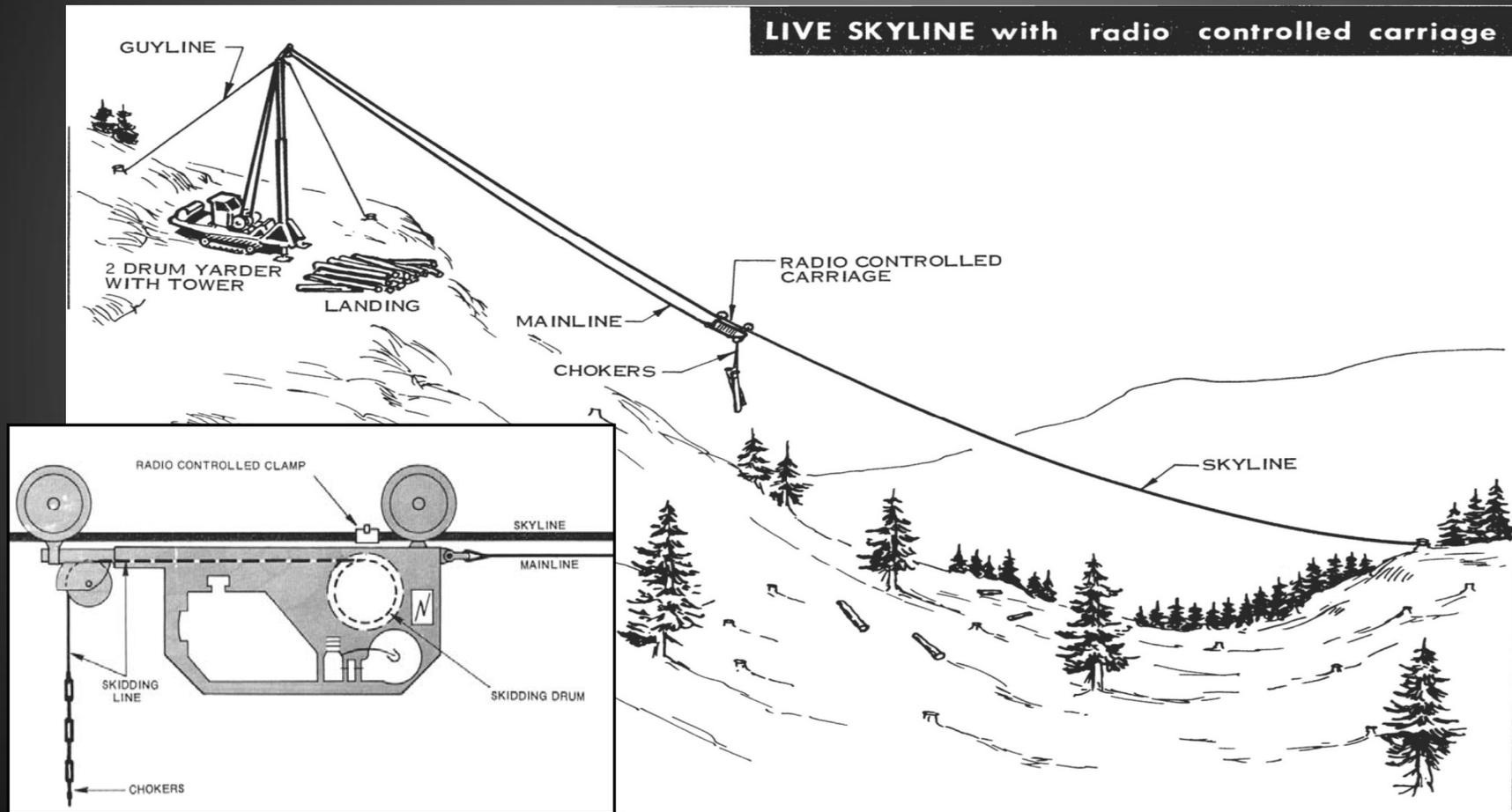


# Cable Yarding Systems

- **Skyline**
  - Properly rigged combined with a slackpulling carriage this system provides partial or full suspension of the turn/log over the ground
  - Higher payloads ~ increased efficiency

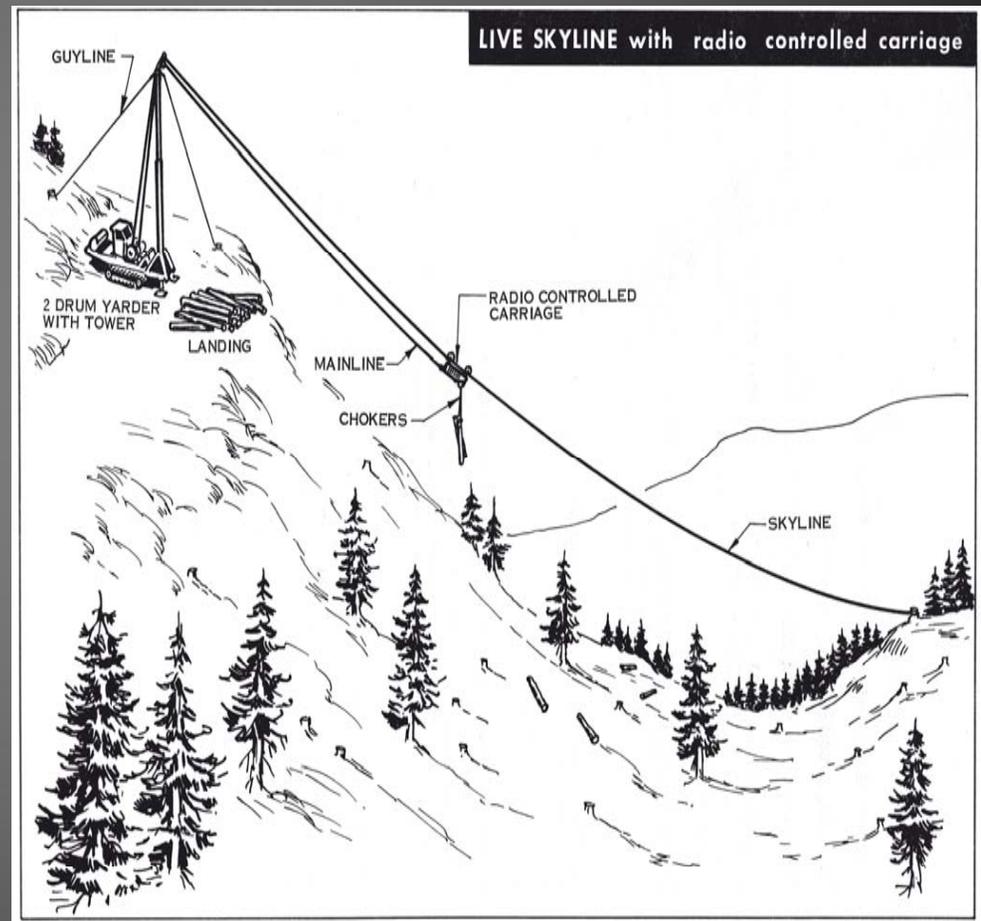
# Live or Standing Skyline

UW

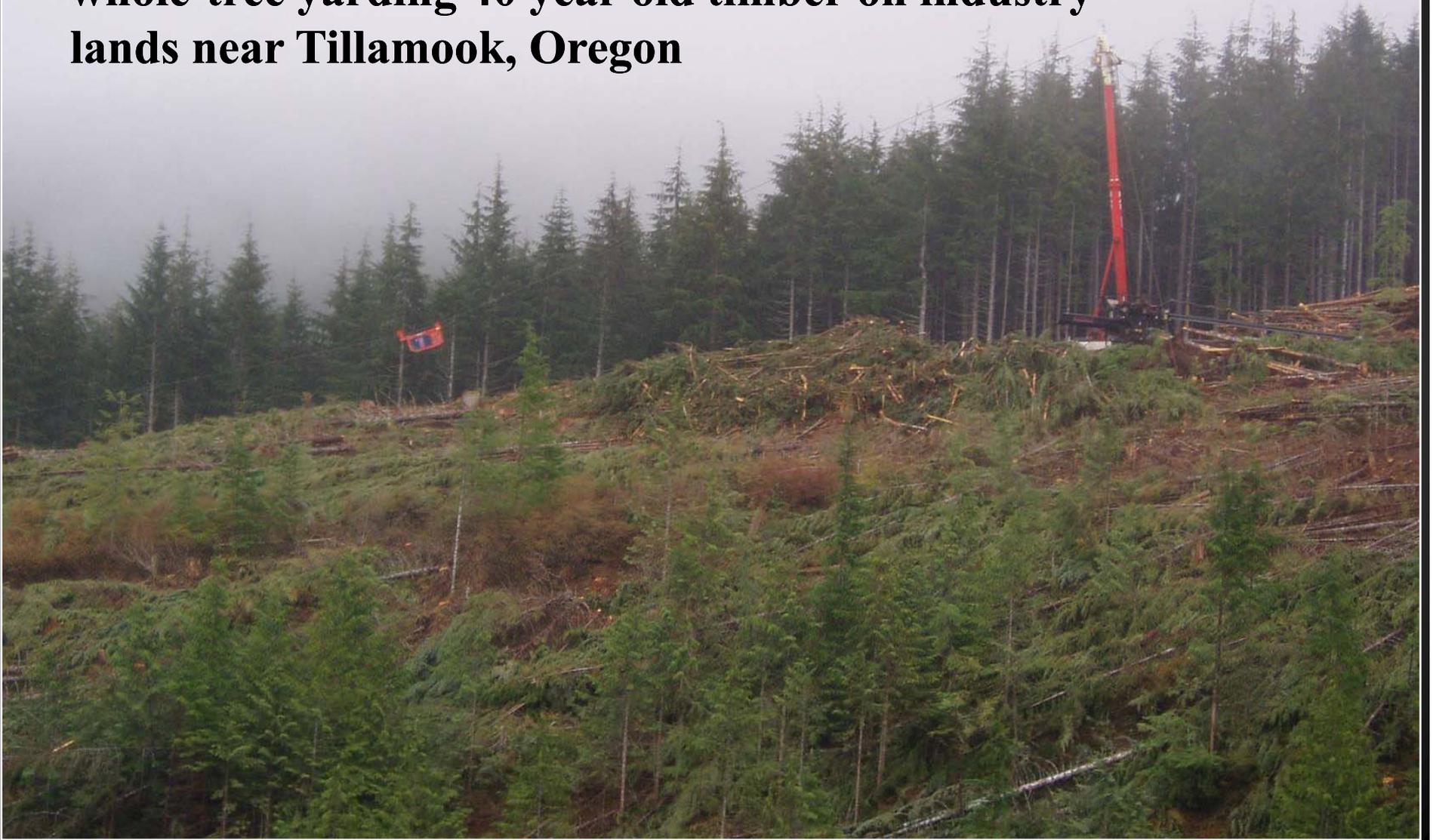


# Skyline system (Live skyline - true)

- Cables suspended between tower and anchor (tailhold)
- Skyline can be raised and lowered (live)
- Have lift/suspension
- Carriage rides on skyline



**Madill 172B in a “Live Skyline” mode with a radio-controlled slack-pulling carriage, skyline whole-tree yarding 40 year old timber on industry lands near Tillamook, Oregon**



# Thunderbird Swing yarder operating in a “Running Skyline” mode



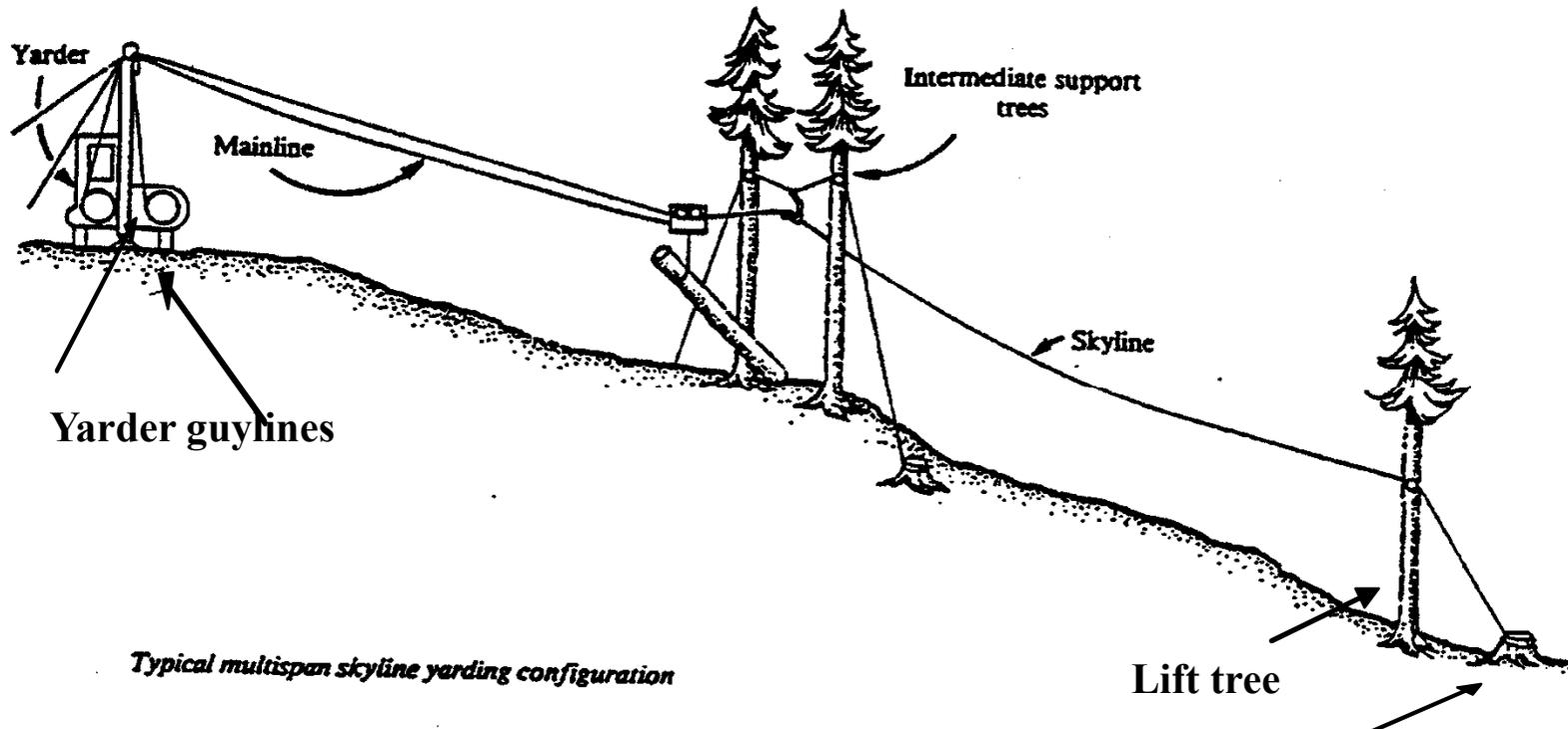
# Cable Yarding Systems

- **Multi-span standing skyline**
  - Convex slopes
  - Long consistent slopes
  - Allows small yarders (shorter tower heights) to operate on longer yarding distances
  - ***DOES NOT SOLVE PROBLEMS DUE TO POOR LAYOUT AND PLANNING***

# Multi-span Yarding

- **Allows yarding convex or long slopes with a smaller tower**
- **Requires expertise in layout, rigging**
- **Requires additional recon for support trees, lift trees and anchors**
- **Lower payloads due to decreased deflection  
~ increased costs**

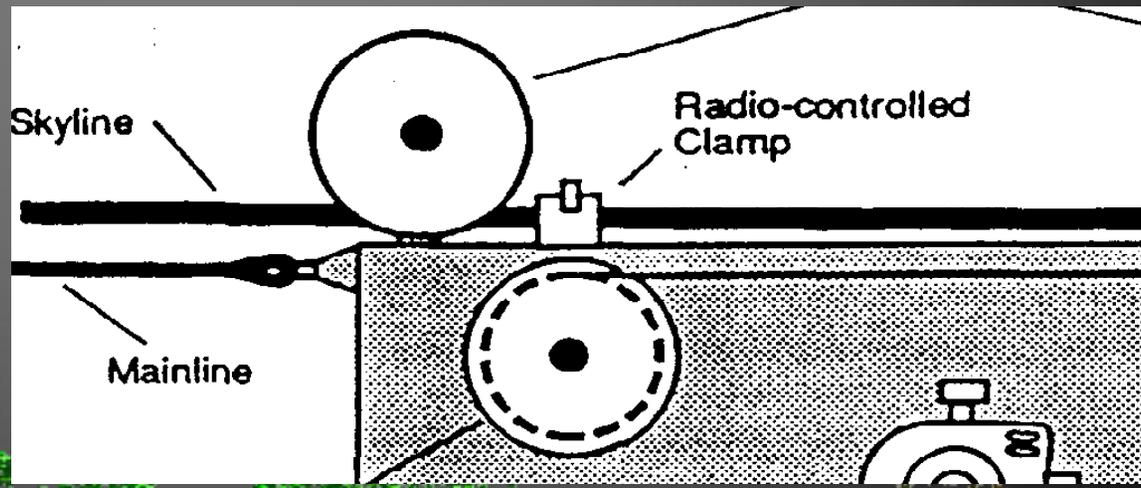
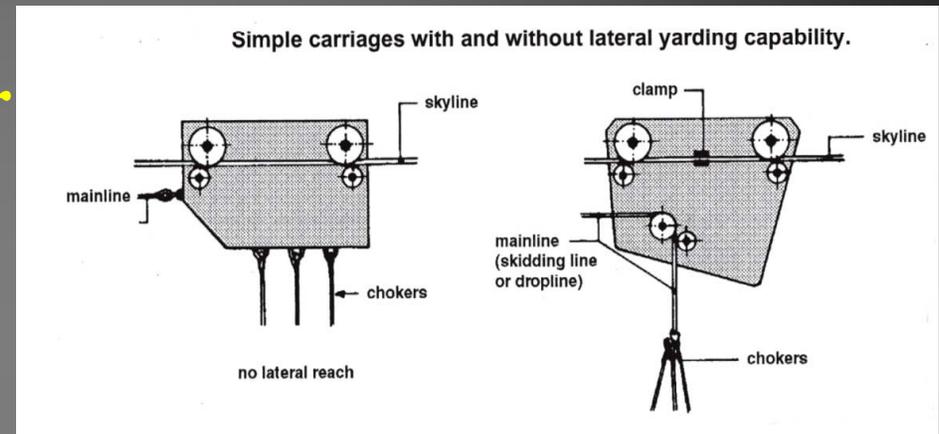
# Multi-span Standing Skyline System



Tailhold anchor

# Carriages

- **Lateral reach crucial for complex silvicultural prescriptions**
- **Typical lateral reach ~ 100ft**
- **Slack-pulling**
  - Manual
  - Mechanical
  - Motorized



# Some examples of motorized carriages with Lateral Reach

- Eagle I-IV or Eaglet, Danebo MSP, Boman Skycar
- Weights 1200 - 2200 lbs for motorized carriages



Type of System and System Crew	Total Monthly Owning & Operating Costs (1000 \$)	Economical External Yarding Distance Limit (m)	Truck Loads <sup>(1)</sup>	Production Cost (US\$/m <sup>3</sup> )
Standing Skyline - small tower 1 log loader 5-man crew, +3 fallers	42-48	250-300	2-5 <sup>4)</sup>	32-100
Live Skyline - large tower 1 log loader 7-man crew +3-4 fallers	64-67	400-600	12-15 <sup>2)</sup> 7-12 <sup>3)</sup>	13-20 25-40
Helicopter -medium size 2 log loaders 14-man crew +6-8 fallers	370-420	1500-2000	20-24 <sup>2)</sup> 11-15 <sup>3)</sup>	56-64 105-133



# Helicopters

- **Expensive**
- **Complex, detailed planning**
- **Logistics, from operation to truck haul**
- **Think 5x before contemplating helicopters**



# LOADING EQUIPMENT

**Boom Loaders**

**Heel Boom**

**\$130.00 Per Hour**

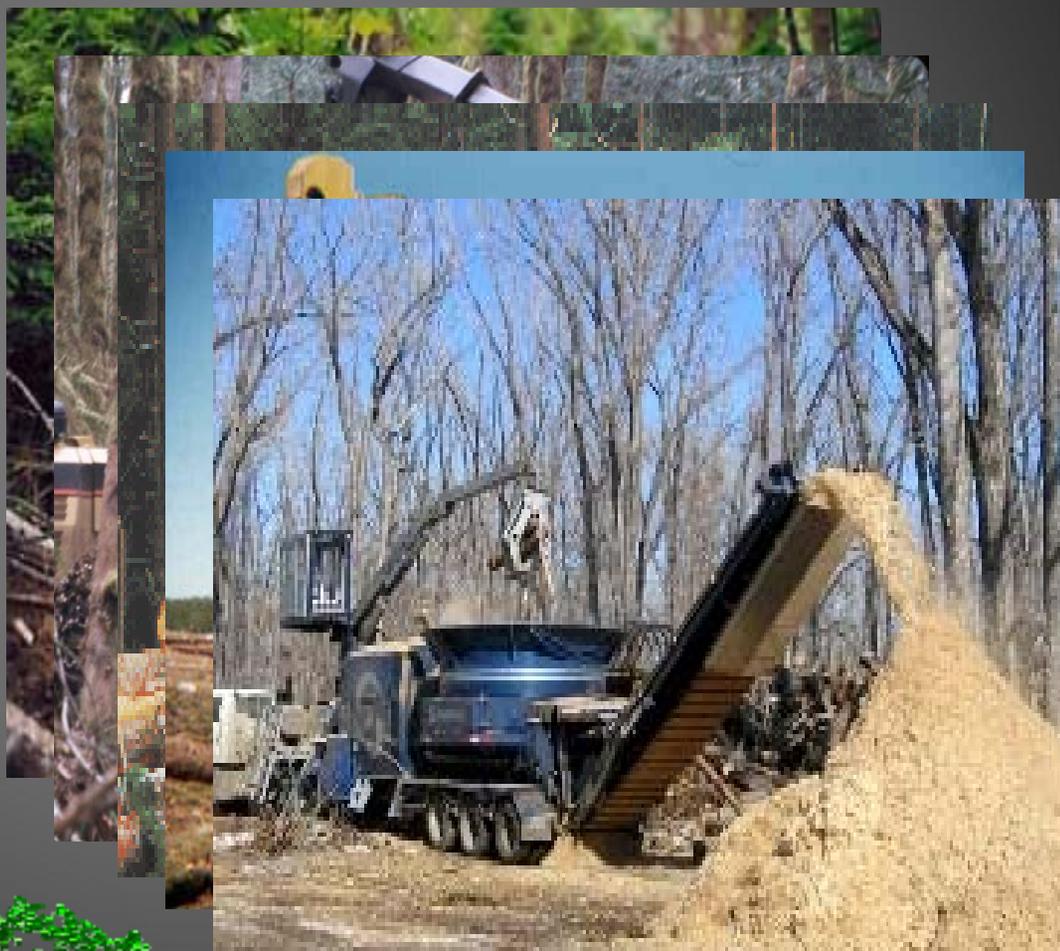
**BNT (Butt and Top)**

**\$130.00 Per Hour**



# PROCESSING

- Occurs at Stump or Landing
- Whole Tree to Transportable Product
- May Occur in Steps
  - Pre-Bunching
  - Topping



# Hauling (secondary transport)

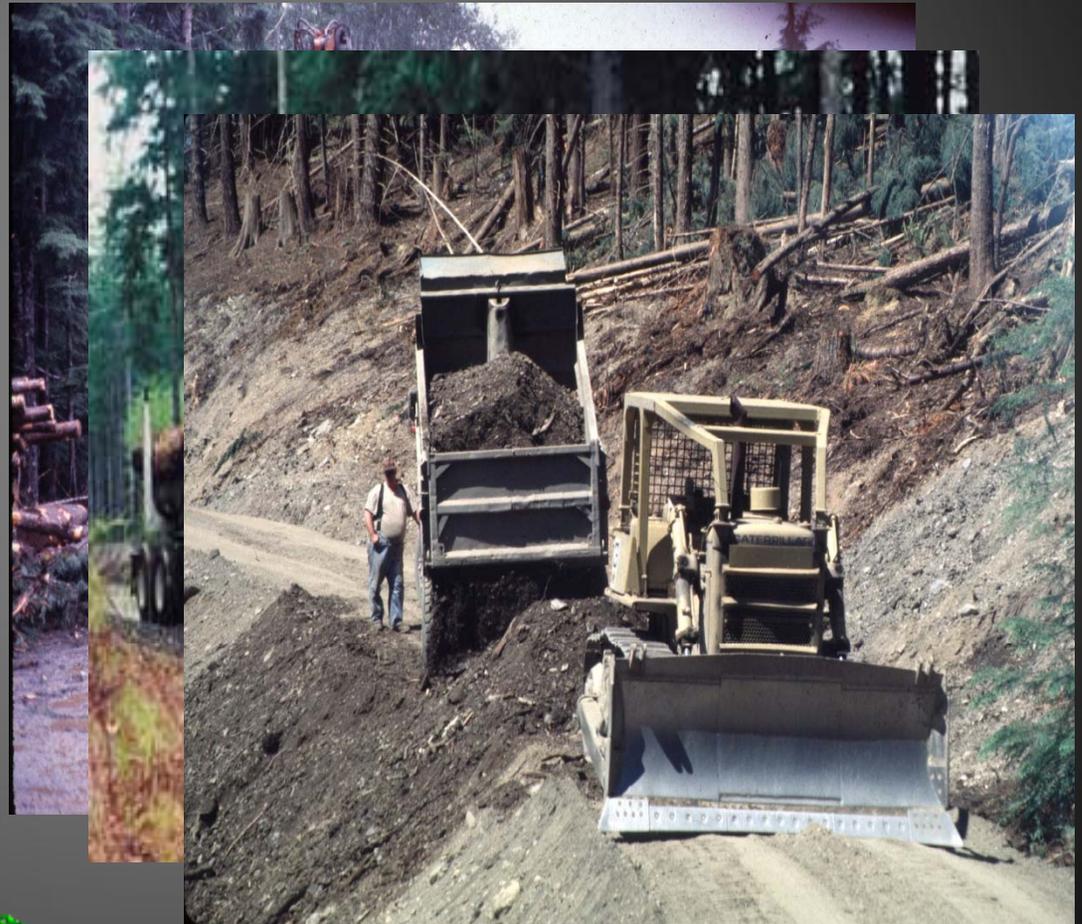
Typical log truck  
with 3-5 MBF per  
truck load

Costs ~ \$75/hr



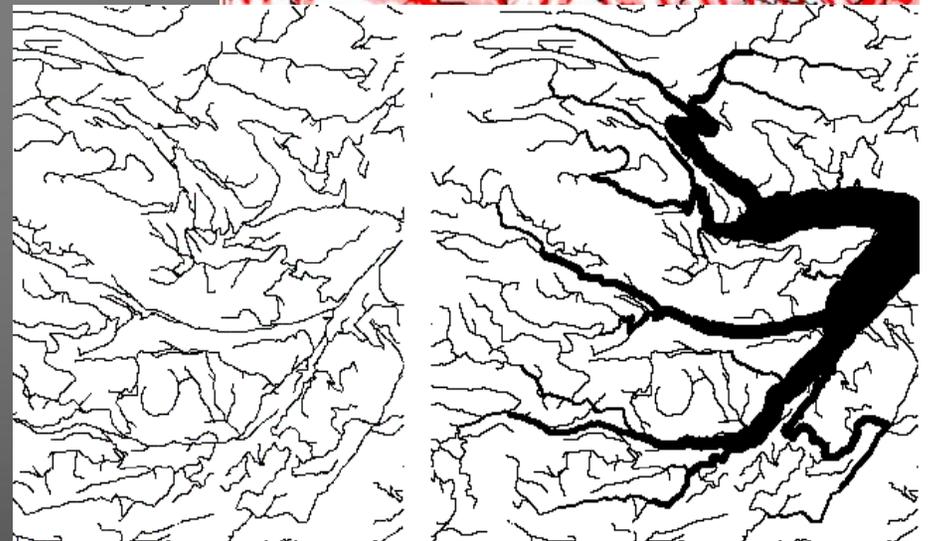
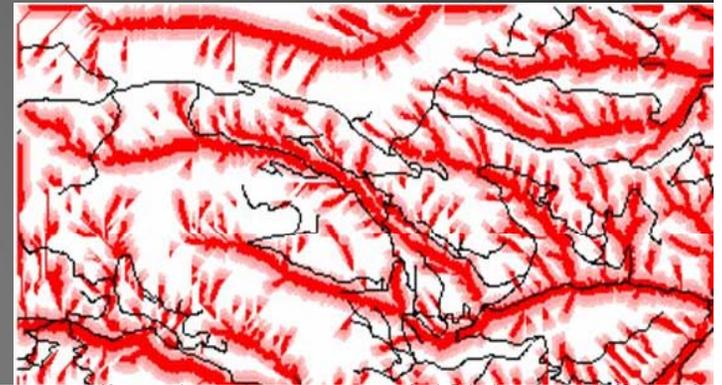
# LOADING / HAULING

- Occurs at Landing
- Landing Connected to Road System



# Truck haul and sediment issues

- Truck haul
- Road-stream proximity
- Road construction / maintenance
- Issue of permanent / temporary roads
- Whole issues of sediment generation and delivery



# Equipment and Expertise Differences

UW



*Clearcutting vs. thinning*



# Small Cable Yarder

- **Koller K300, K501; Skylead; TMY40**
  - Use: smallwood thinnings, low value rehabilitation
  - Tower height < 40 feet
  - Optimum yarding ~ 800-1000 feet
  - Crew: 2 – 5 persons
  - Production: 2-7 loads day
  - Landing size: roadside up to 50 feet
  - Daily O&O Costs for side: ~\$ 2500-3000



**Koller K501**



**Koller K501**



**Koller K300**

# Medium Cable Yarder

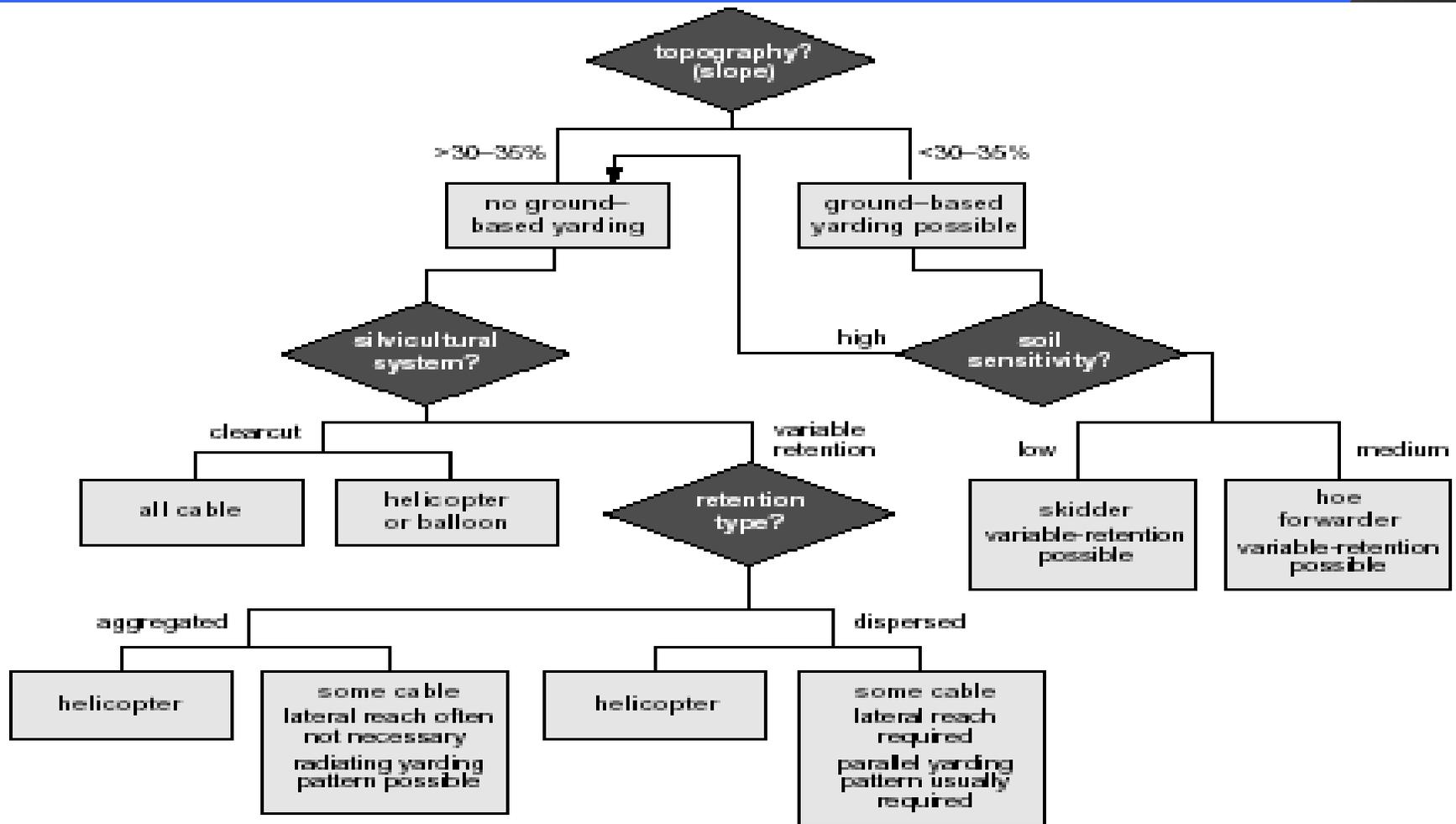
- **Madill 071, Madill 172, Madill 255, TMY50, TMY70, Diamond**
  - **Use: older thinnings, clearcuts in medium sized wood, some large sticks**
  - **Tower height ~ 50-72 feet**
  - **Optimum yarding ~ 1000 – 1200 feet**
  - **Crew: 5 – 7 persons**
  - **Production: 7-15 loads day (clear cut)**
  - **Landing size: min. 50 feet in one dimension**
  - **Daily O&O Costs for side: ~\$ 3000-3500**

# Cable System Thinning



- 50' tower = 1" Skyline/ SWL 30,000 lbs.
- Slack Pulling Carriage (Eaglet) 1,200 lbs.
- Medium Log Loader
- Stroke Delimber
- Daily O&O Costs for side: ~\$ 3200.

# Harvest systems decision matrix

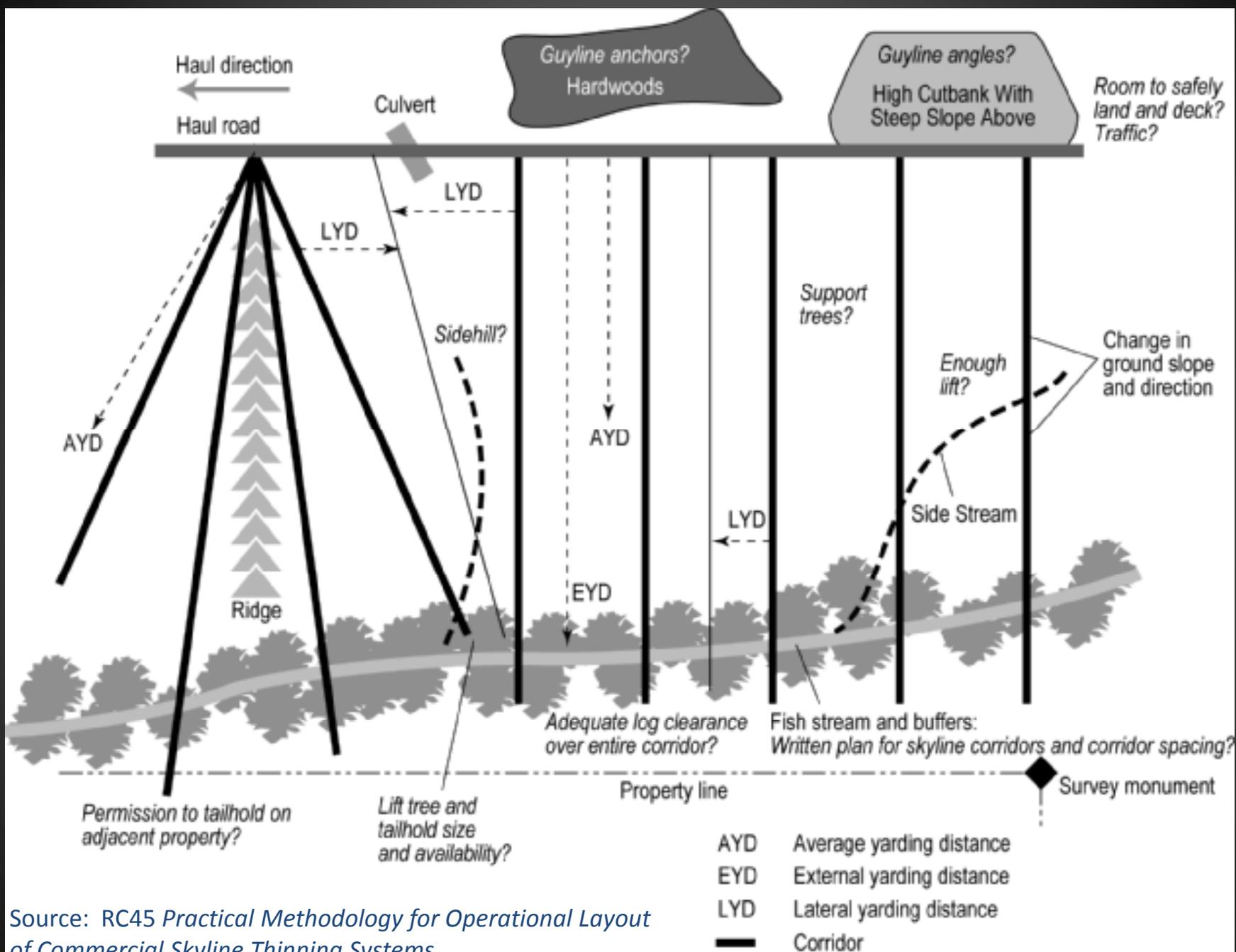


# Operational Layout

- **Several things to consider when planning for a cable yarding system....**
  - **Fitting equipment size to log/turn size and terrain**
  - **AYD = average yarding distance**
  - **LYD = lateral yarding distance**
    - 75-100 ft thinning
    - 200 ft max. clearcut
  - **EYD = external yarding distance**

## Examples of log sizes and log weights. Log weights affect payload and skidding productivity

Log Diameter (cm)	Log Length (m)	Volume (m <sup>3</sup> )	Green Weight (kg) (based on 750 kg/m <sup>3</sup> )
20	12	0.38	285
50	24	2.36	1770
tree length, to 10 cm top	24	0.75	562



Source: RC45 *Practical Methodology for Operational Layout of Commercial Skyline Thinning Systems*

# Operational Layout

- **Access, turnarounds**
- **Time of year (rock vs. dirt)**
- **Landing locations and size**
- **Adequate tree size and availability for rigging anchors for guylines, tailholds, support and lift trees**
- **Uphill versus downhill yarding**

# Operational Layout

- **Problem areas for lift and deflection, maximum external yarding distance**
- **Sequence and timing of operations**
- **Sidehill yarding (avoid it)**
- **Keep boundaries along topog breaks and straight as possible**
- **And more.....**

# Adequate Tree Size and Anchors

Table 2. Recommended minimum diameters (in., measured at 4.5 ft) for west coast Douglas-fir tail trees.<sup>1,2</sup>

Skyline size (in.)	Rigging height (ft)					
	30	40	50	60	70	80
5/8	13.5	16.0	18.5	20.5	22.5	24.5
3/4	14.5	17.0	19.5	22.0	24.5	26.5
7/8	15.0	18.0	20.5	23.0	25.5	28.0
1 1/8	16.0	19.0	21.5	24.5	27.0	29.0
1 1/4	16.5	20.0	22.5	25.5	28.0	30.5
1 1/4	17.5	21.0	23.5	26.5	29.0	31.5
1 3/8	18.0	21.5	24.5	27.5	30.0	32.5
1 1/2	18.5	22.5	25.0	28.5	31.0	33.5
1 5/8	19.5	23.0	26.0	29.0	31.5	34.5
1 3/4	20.0	23.5	26.5	30.0	32.5	35.5
1 7/8	20.5	24.5	27.5	30.5	33.5	36.5
2	21.0	25.0	28.5	31.5	34.5	37.5

<sup>1</sup>OR-OSHA Chapter 437, Division 7.

<sup>2</sup>Table is for sound, straight Douglas-fir. Add 2 in. to diameters when using other coniferous species.

# Adequate Tree Size and Anchors



The holding power of stumps

$$F = 0.285 * D^{**1.65}$$

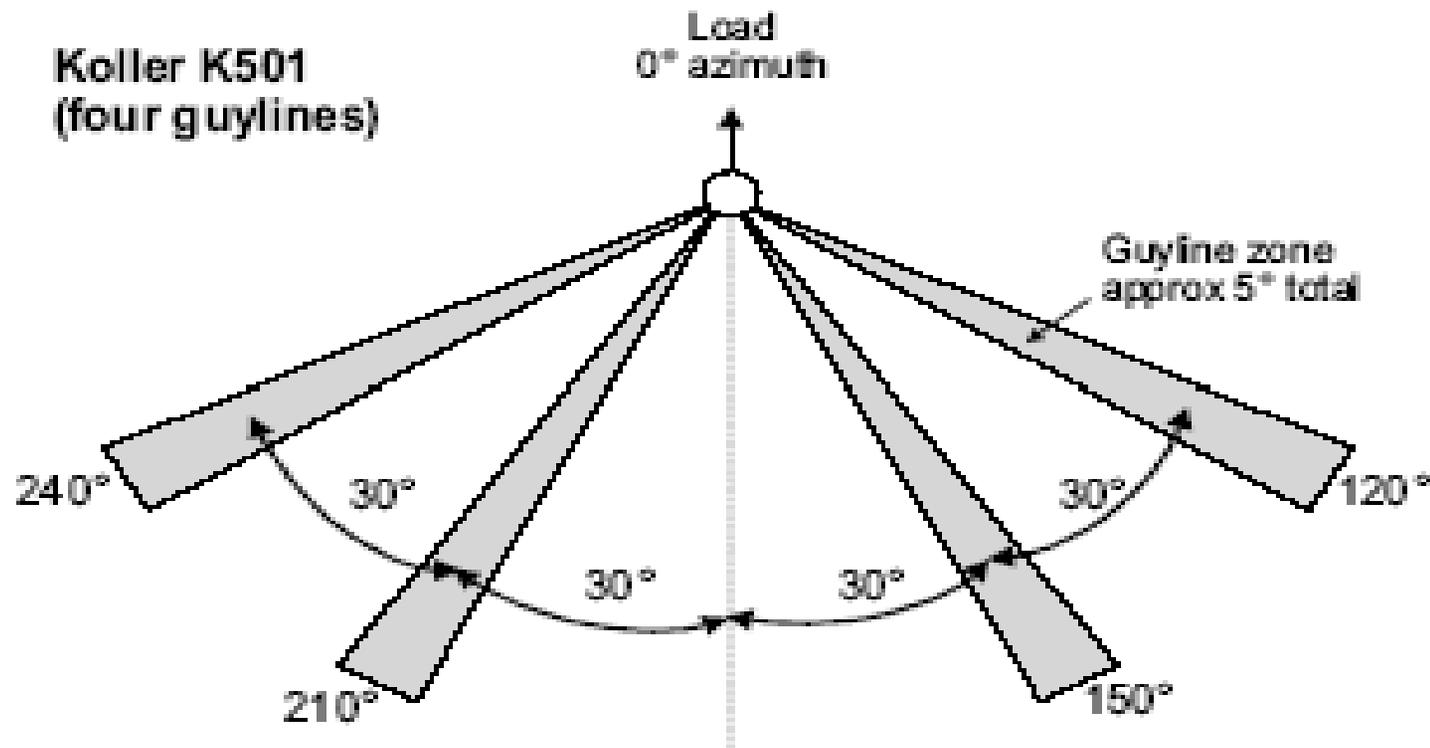
where

$$F = \text{kips (1000\#)}$$

$$D = \text{stump diameter (inches)}$$

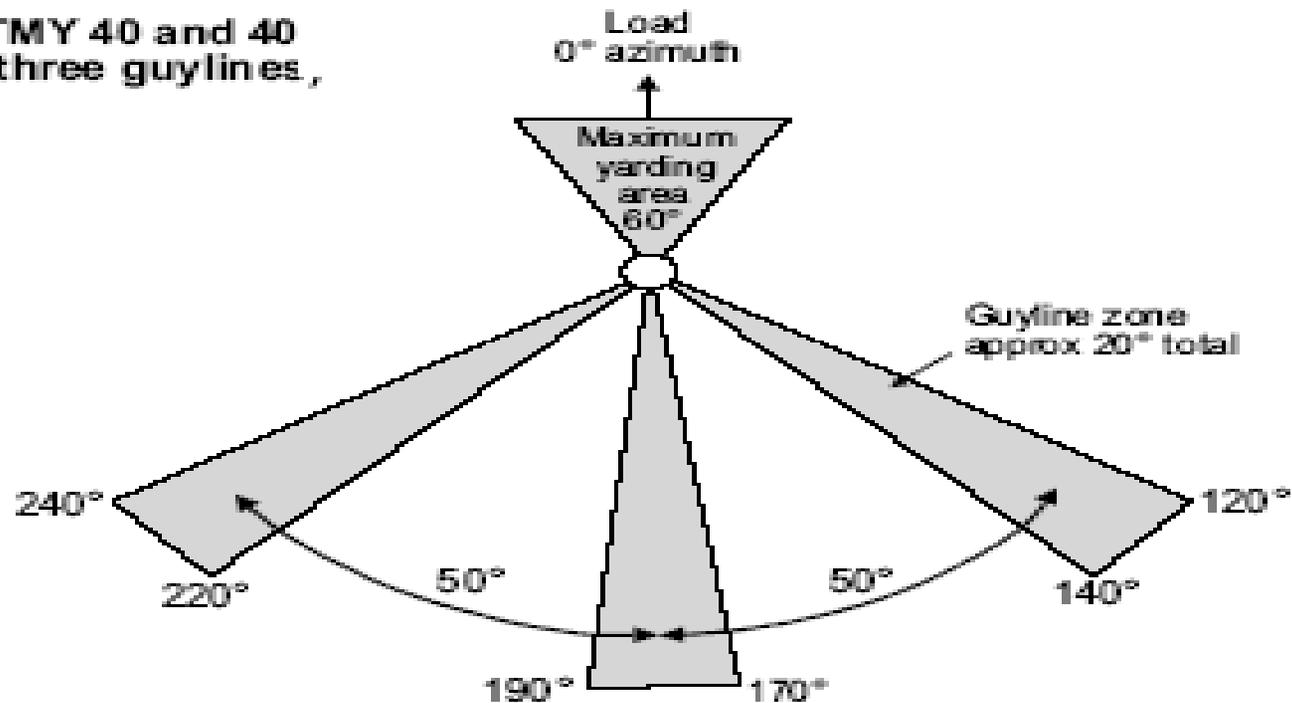
Source: Jim English

# Adequate Tree Size and Anchors - Configurations



# Adequate Tree Size and Anchors - Configurations

TMY 40 and 40  
(three guylines,



# Percent of land area affected by logging systems

	Area affected in percent	
Operational Areas	Cable Systems	Ground-Based Systems
Landings	4.1	6.4
Spur roads	2.6	3.5
Cable corridors or skid trails	9.2	21.4
Total	15.9	31.3

# Equipment and Expertise Differences

UW



*Clearcutting vs. thinning*



# Cost Variables

- **Layout-Planning**
- **Stump-to-Truck**
  - **Falling & bucking**
  - **Yarding**
  - **Loading**
- **Haul**
- **Road Construction-Maintenance**

# Layout

- **Estimate \$2/mbf - \$8/mbf**
- **Factors**
  - **Map material**
  - **Stocking, volume per acre removal**
  - **Difficulty of terrain, brush**
  - **Environmental restrictions (buffers, leave areas, etc.)**
  - **Experience level of layout person**

# Falling & Bucking

- **Clearcut: medium to large clean wood**
  - \$15/mbf - \$25/mbf
- **Thinning:**
  - **Small diameter, first entry**
    - \$35/mbf - \$45/mbf
  - **Second entry**
    - \$25/mbf - \$35/mbf

# Falling & Bucking

- **Factors**
  - **Stocking, volume removed per acre**
  - **Slope steepness, brush**
  - **Full limb and buck or partial**
  - **Species**
  - **% live crown**
  - **Wage per volume or per day**
  - **Average tree and piece size**

# Cable Yarding

- **Clearcut**
  - **Small to medium sized timber**
    - **\$110/mbf - \$150/mbf**
  - **Medium to large sized timber**
    - **\$90/mbf - \$130/mbf**

# Cable Yarding

- **Thinning**
  - **Small timber**
    - \$120/mbf - \$300+/mbf
    - ~3- 4 truck loads/day
  - **Medium timber**
    - \$110/mbf - \$200/mbf
    - ~ 4 – 5 truck loads/day

# Cable Yarding

- **Factors – that affect production**
  - Volume per acre removed
  - Average tree size, piece size
  - Payload
  - AYD, EYD, LYD
  - Landing size and layout
  - Single span vs. multi-span
  - Uphill vs. downhill yarding

# Processing

- **Thinning (one chaser, 9.6 mbf/day)**
  - \$20-\$30/mbf
  - or small Processor
- **Clearcut (two chasers, 38 mbf/day)**
  - \$10-\$13/mbf
  - or Processor plus one chaser

# Loading

- **Small wood – 100+ pieces/load**
  - 3000 – 3200 bf/load
  - ~\$50/mbf (includes a frustration factor)
- **Small wood – 50-100 pieces/load**
  - 3200 – 3800 bf/load
  - ~\$20-30/mbf

# Loading

- **Medium wood – 20 – 50 pieces/load**
  - 3800 – 4200 bf/load
  - \$12/mbf
  
- **Large wood - < 20 pieces/load**
  - 4200 – 5000 bf/load
  - \$10 - \$12/mbf

# Hauling

- **Primarily a factor of haul distance and volume per load**
- **Example:**
  - **Truck costs ~ \$75/hr**
  - **Haul time ~ 2 hrs**
  - **Cost for 3200 bf load = \$46.88/mbf**
  - **Cost for 3800 bf load = \$39.50/mbf**

# Other Costs for Comparison

- **Roads**
  - **Initial cost**
  - **Long-term maintenance cost**
  - **Volume removed over system during lifetime of road**

# Other Costs for Comparison

- **Roads (cont.)**
- **Tough (expensive) construction**
  - \$100,000 construction + \$2000/yr for 50 years = \$200,000
  - Remove 100 mmbf in 50 years
- **Cost = \$200,000/100,000 mbf = \$200/mbf**

# Cable/Region 6 Costing

- **Regeneration Harvest**
  - **Daily Cost: \$3600-\$3900**
  - **Daily Production: 75 mbf**
  - **Payload  $\approx$ 8000 lbs**
  - **Stump to Truck: \$96/mbf**
- **Thinning Harvest**
  - **Daily Cost: \$3200-\$3500**
  - **Daily Production: 15 mbf**
  - **Payload  $\approx$ 2500 lbs**
  - **Stump to Truck: \$240/mbf**

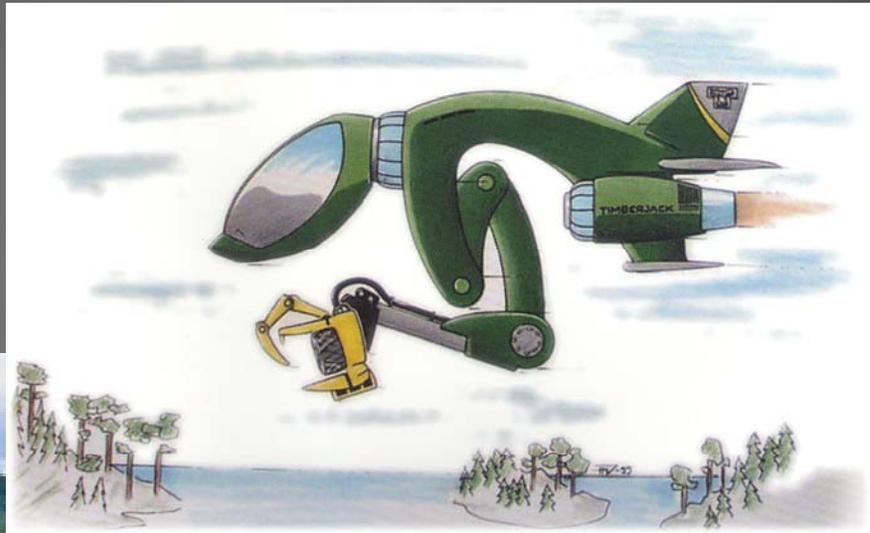
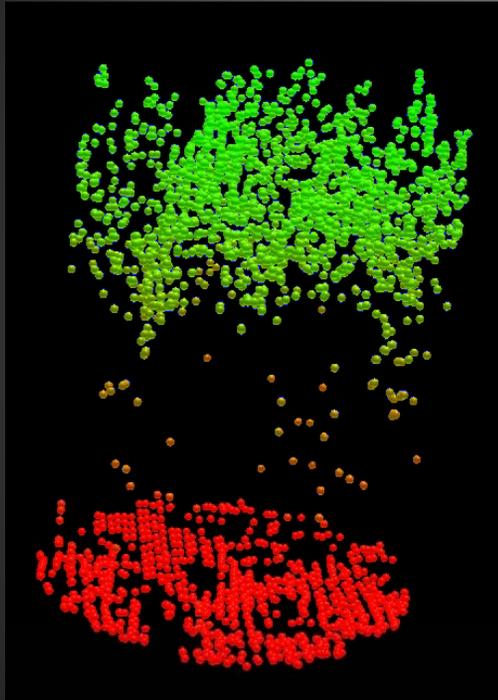
# ROAD AND HARVEST PLANNING – BRINGING IT ALL TOGETHER

- Harvest operations are about getting timber from the stump to the mill at the lowest economic and ecologic cost. :
- Selection of the appropriate system is based on a number of variables, including
- topography (slope steepness and variability);
- soil (saturation, composition, sensitivity to disturbance);

# ROAD AND HARVEST PLANNING – BRINGING IT ALL TOGETHER

- silvicultural system (level of retention, thinning-clear-cut);
- timber characteristics (log size and volume per hectare);
- potential road access constraints
- stream and wetland distribution;
- equipment characteristics and performance (production and cost)
- processing (limbing & bucking) location;
- mill/market requirements

# What's around the corner?!



# Lidar-derived topography



# Tree lists with xyz coordinates, height-diameter, etc

- **Tree Lists from Lidar data**
  - Gives Tree Location based on Canopy Surface Model
  - Derives Height and Diameter
- **Application**
  - Tail Tree and Intermediate Support Locations



# Find Tail Tree Locations with Search on GIS

Select By Attributes

Query Wizard...

Layer: South\_treelist

Only show selectable layers in this list

Method: Create a new selection

Fields:

"FID"	=	< >	Like
"id"	>	> =	And
"x"	<	< =	Or
"y"	_ %	()	Not
"ht"	Is		
"dbh"			

Unique Values

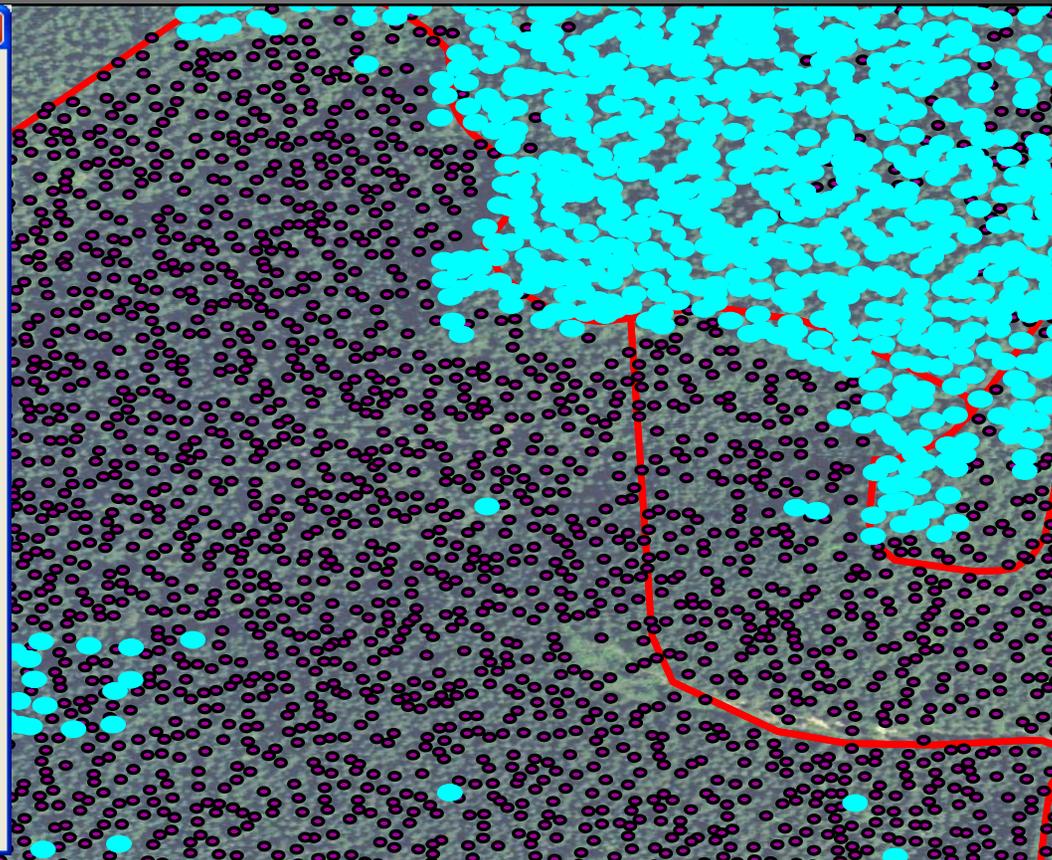
Go To:

Get Unique Values

SELECT \* FROM South\_treelist WHERE:

"dbh" >20

Clear Verify Help Load... Save... Apply Close

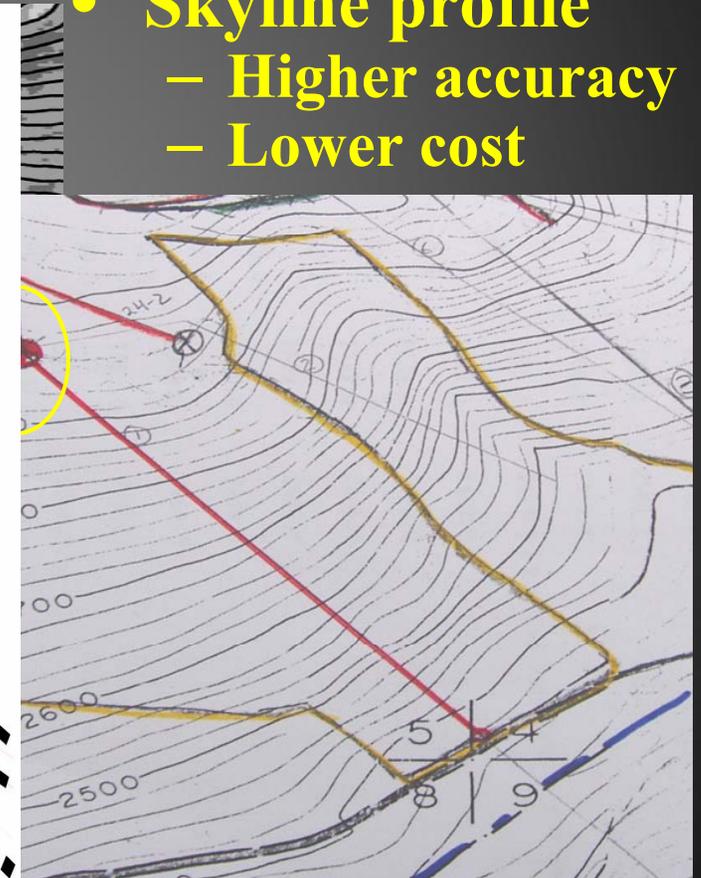
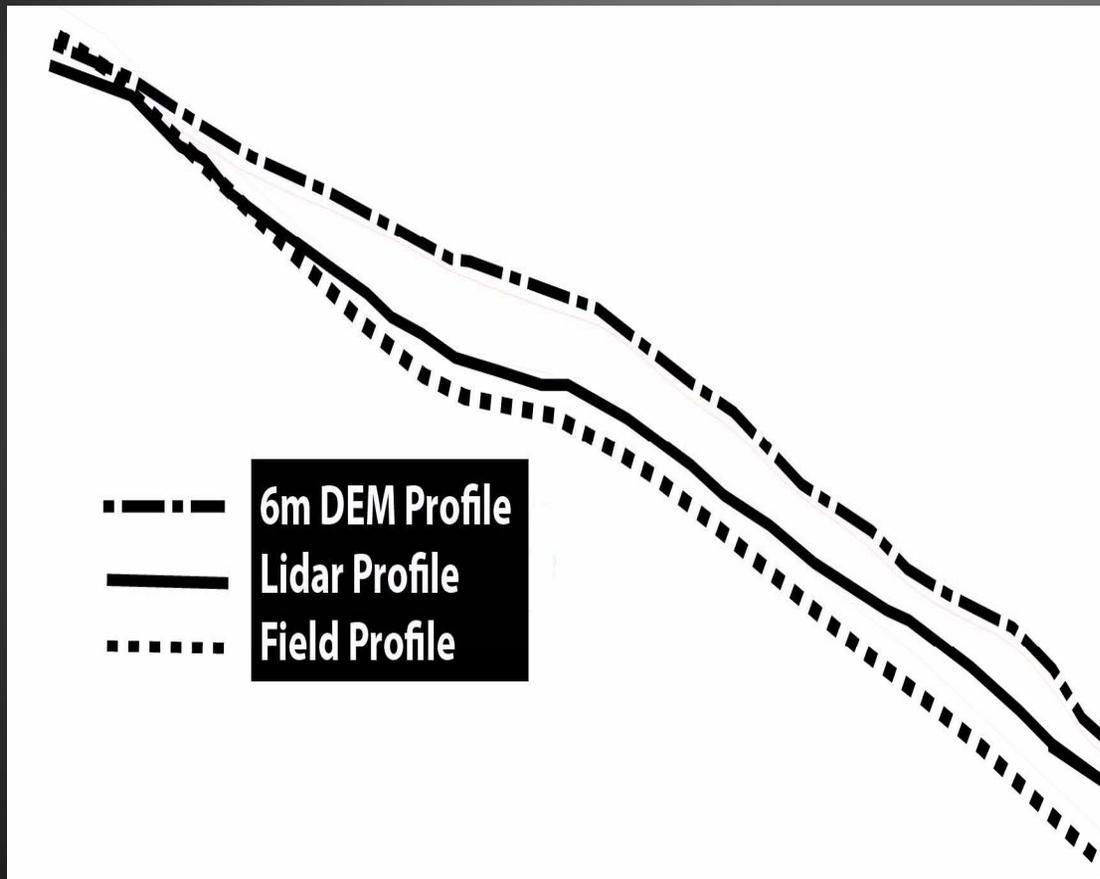


# Skyline Profile Analysis

- **Profile data**
  - DEM's and ArcGIS
  - Topog maps
  - Field measure –
  - **Lidar-derived map profiles better than field measured profiles**

# LIDAR in Skyline Planning

- Skyline profile
  - Higher accuracy
  - Lower cost



# How is the other guy doing it.....

# Thinning operation: 2 person, choker setter runs the yarder, chaser runs the processor, carriages runs on auto-pilot



# Chaser runs processor/grapple, carriage is on auto-pilot out



# Chaser sorts and decks processed logs



# Resources

- *Cable Logging Systems*, Studier & Binkley, 1974, Oregon State University Bookstores
- *Practical Methodology for Operational Layout of Commercial Skyline Systems*, Cornell & Kellogg, 2004, Oregon State University Forest Research Lab, RC45

[http://fcg.cof.orst.edu/structur/pubs\\_view.php](http://fcg.cof.orst.edu/structur/pubs_view.php)

# Resources

- **USFS R6 Forest Products Web Page**

<http://www.fs.fed.us/r6/nr/fp/FPWebPage/FP70104A/FP70104A.htm>

- **WDNR Product Sales**

[http://www.wadnr.gov/htdocs/sales\\_leasing/sales/Appraisals/LOGGING\\_METHOD\\_COSTS\\_3](http://www.wadnr.gov/htdocs/sales_leasing/sales/Appraisals/LOGGING_METHOD_COSTS_3) )