Topics in Forest Transportation Network Design

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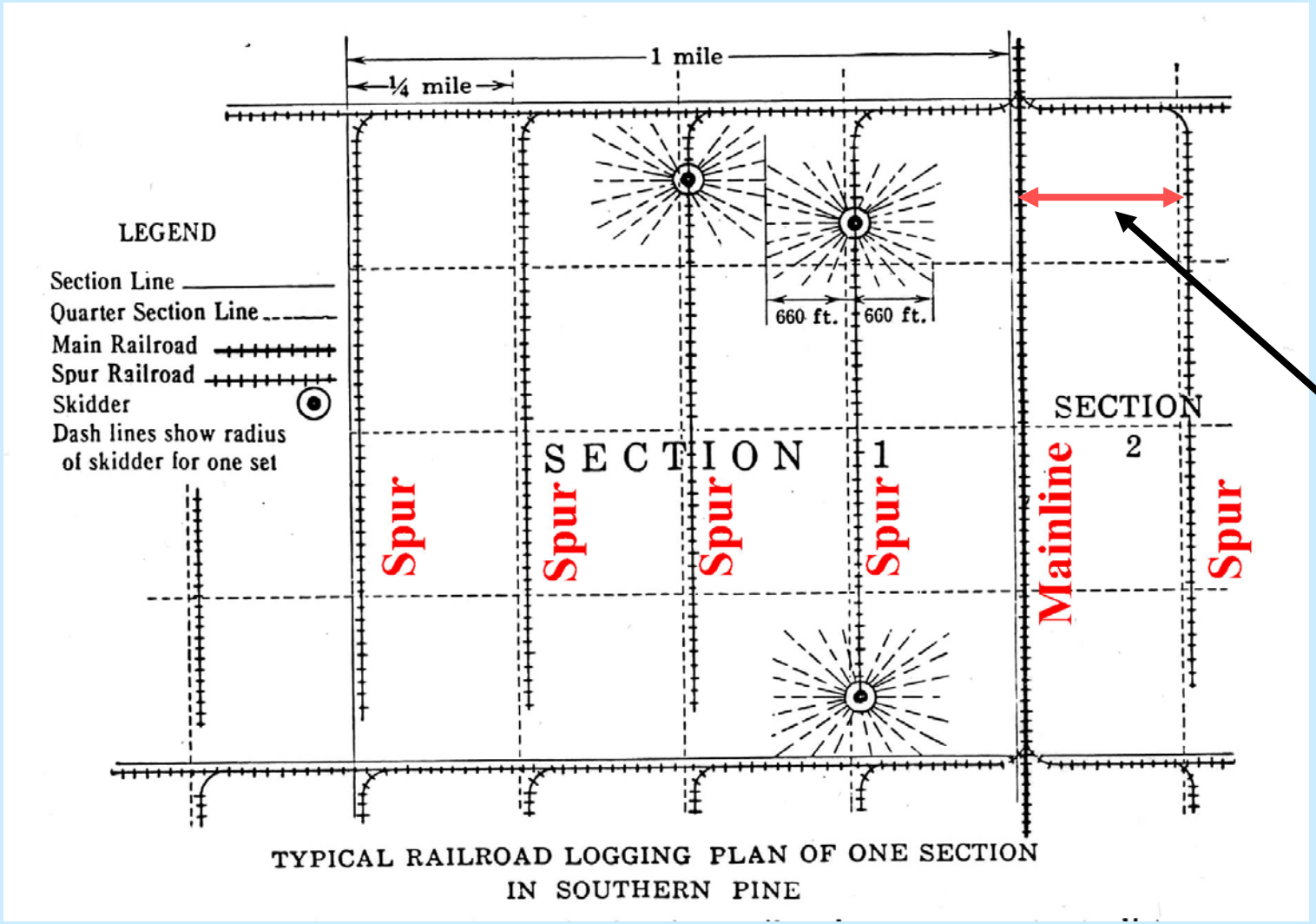
Balancing Transportation Costs

“The skidding distance that gives a skidding cost which, when added to the cost of railroad construction results in the lowest total cost per thousand for both skidding and railroad construction, shows the distance apart that the railroad spurs should be.”

James Walter Girard. 1922. "Tractor and horse skidding in Inland Empire.” The Timberman XXIV(1):66,68,70.

Analysis - Uniform Terrain Conditions



optimal spacing, w^*, is sought

"Based on actual practice in Florida"

Brown, Nelson C. 1934. *Logging Principles and Practices*.

Practical Layout - Optimization

TABLE 9.—*Most economical distances between railroad spurs and the most economical direct-skidding distances; and the combined cost per thousand of railroad construction and skidding*

Operating conditions	Stand per acre	Tractor skidding		Horse skidding	
		Distance between railroad spurs [1]	Combined cost	Distance between railroad spurs [1]	Combined cost
	M ft. b. m.	*Feet*	*Dollars*	*Feet*	*Dollars*
0 to 15 per cent slope:					
Summer work—					
3 to 5 log timber	10	2,800	1.52	2,000	2.02
	20	2,000	1.18	1,200	1.49
9 to 12 log timber	10	2,400	2.09	1,600	2.56
	20	1,800	1.71	1,200	1.94
Winter work—					
3 to 5 log timber	10	3,400	1.50	2,200	1.88
	20	2,400	1.22	1,400	1.46
9 to 12 log timber	10	3,000	2.09	1,600	2.51
	20	2,000	1.76	1,200	1.91
15 to 30 per cent slope:					
Summer work—					
3 to 5 log timber	10	5,800	2.05	4,000	2.90
	20	3,600	1.57	2,400	2.08
9 to 12 log timber	10	5,000	2.93	3,000	3.98
	20	3,000	2.35	2,000	2.92
Winter work—					
3 to 5 log timber	10	6,000	1.97	5,200	2.43
	20	3,800	1.50	2,800	1.80
9 to 12 log timber	10	6,000	3.30	4,400	3.59
	20	2,600	2.64	2,000	2.85

[1] Twice the maximum direct distance.

1

5

2

3

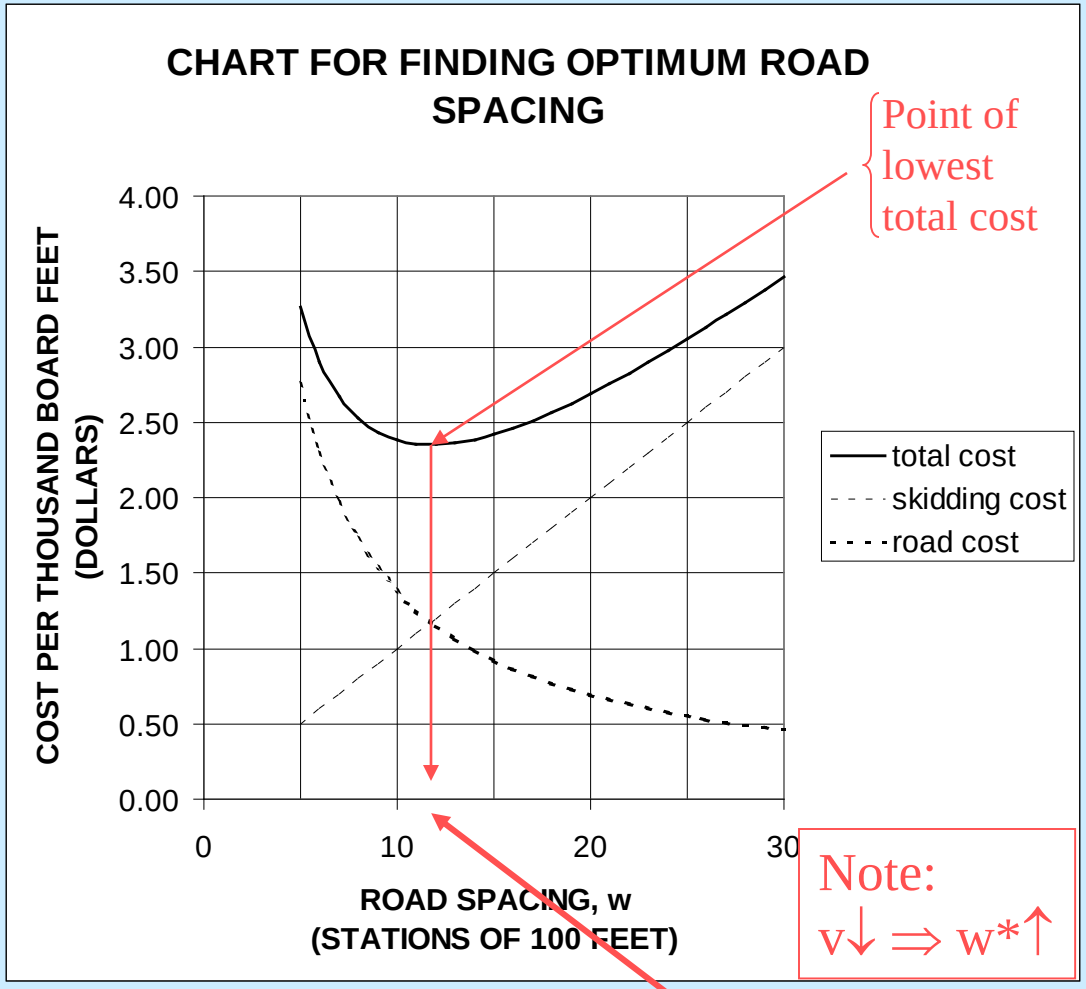
4

w*

Important factors:
(1) skidding method,
(2) ground slope,
(3) season of the year,
(4) size of the logs,
(5) volume per acre

Bradner, Klobucher, Girard, and Fullaway. 1933. "An analysis of log production in the `inland empire' region" USDA Tech. Bull. No. 355.

A Simple Cost Trade-off Model



Skidding directly to the road from both sides.

Skidding cost is $0.40 per Mbf per station.

Road construction cost is $38.00 per station.

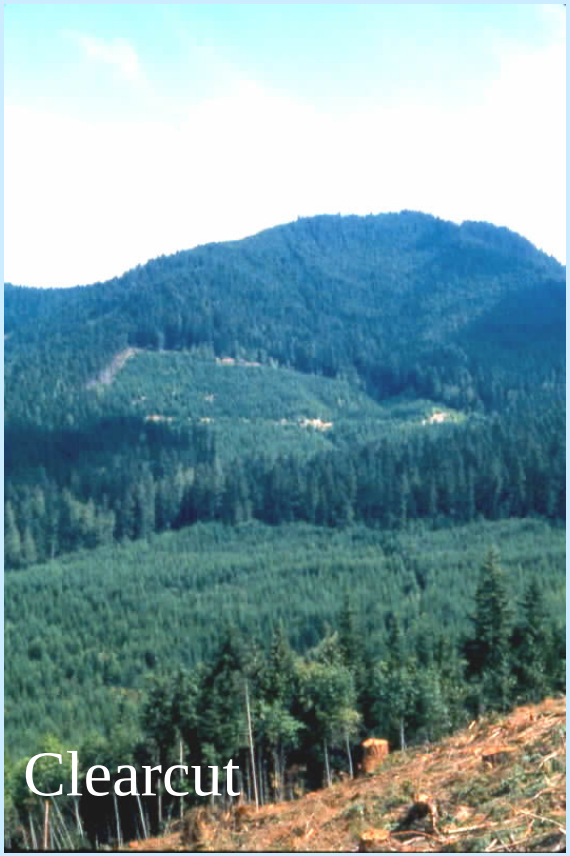
Volume per acre cut (v) is 12 Mbf

Optimum spacing, w*, is 11.7 stations (1170 feet).

Pearce, Kenneth. 1960. Forest Engineering Handbook.

$$w^* = (1652/v)^{½} = (1652/12)^{½} = 11.7$$

Silvicultural Prescription Impact



Lower volumes removed per hectare will increase the spacing between roads

Note:
$v\downarrow \Rightarrow w^*\uparrow$

Distance between roads increases

The number of years required to harvest an area accessed by a road system will also influence road spacing

Yarding Technology Impact

Changes in yarding methods can change the optimal road spacing

helicopter

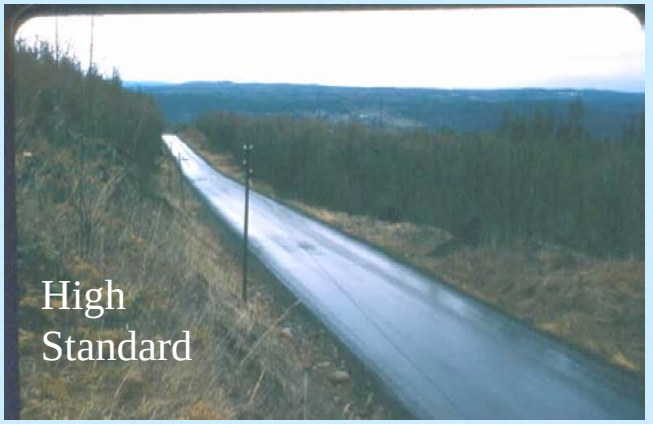
forwarder

skidder

horse

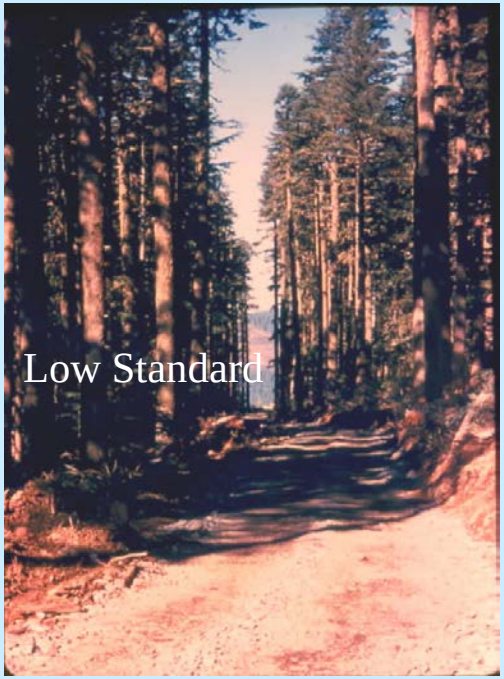
Distance between roads increases

Road Cost Impact



High Construction Cost
Low Timber Hauling Cost

Moderate Construction Cost
Moderate Log Hauling Cost



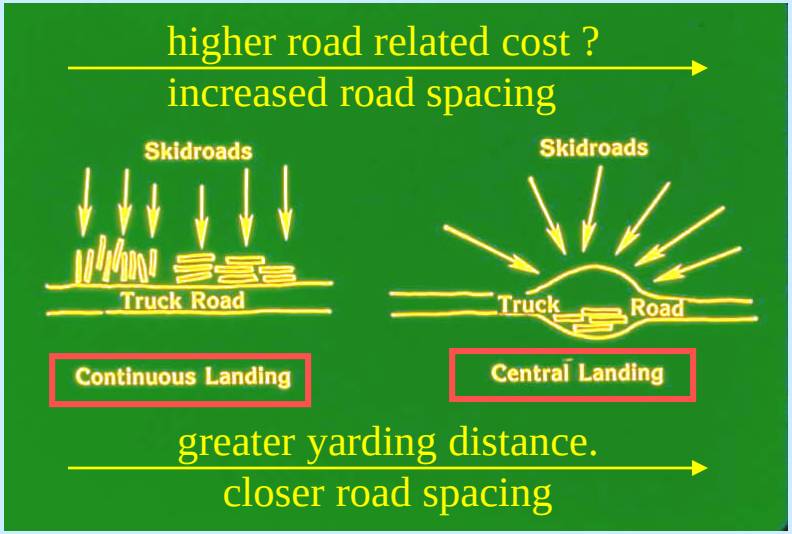
Low Construction Cost
High Log Hauling Cost

Distance between roads increases

Landing Type Impact

Possible increase in road related costs,

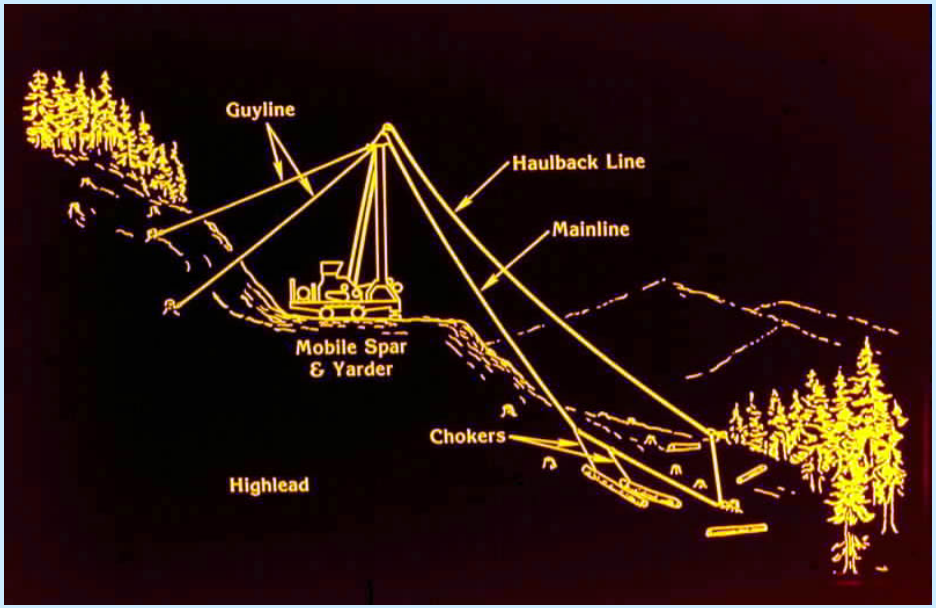
$w^* \uparrow$

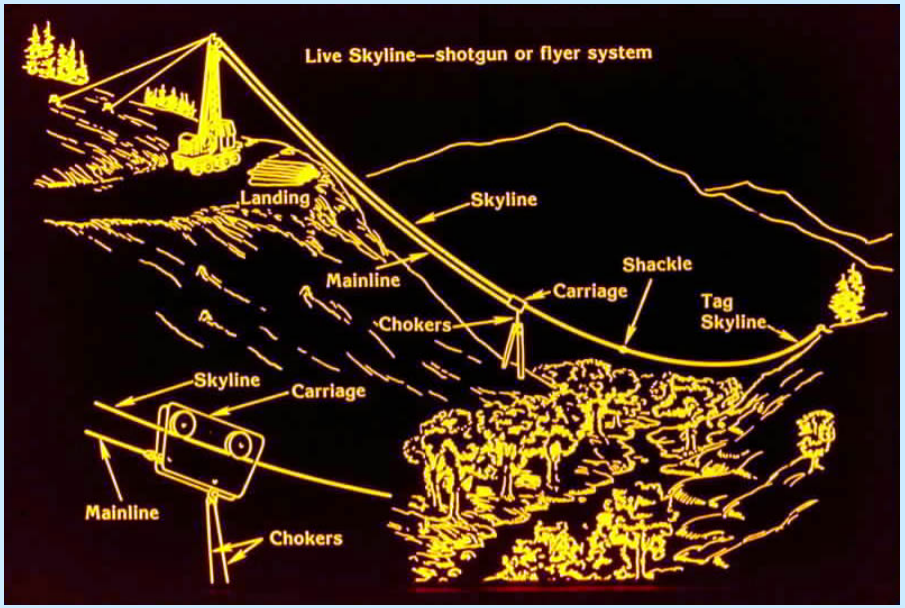


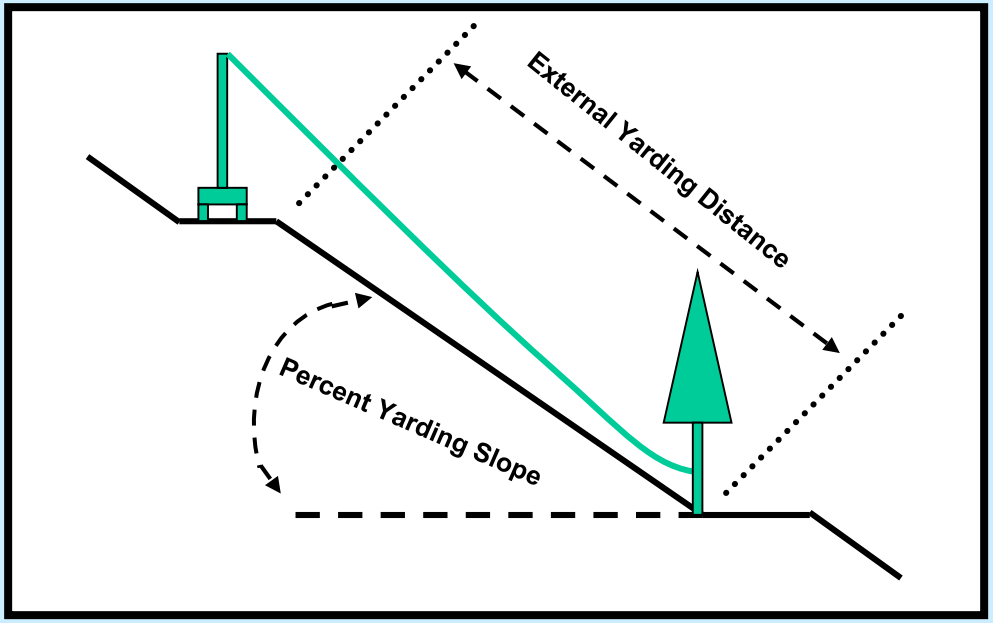
Certain increase in the yarding cost.

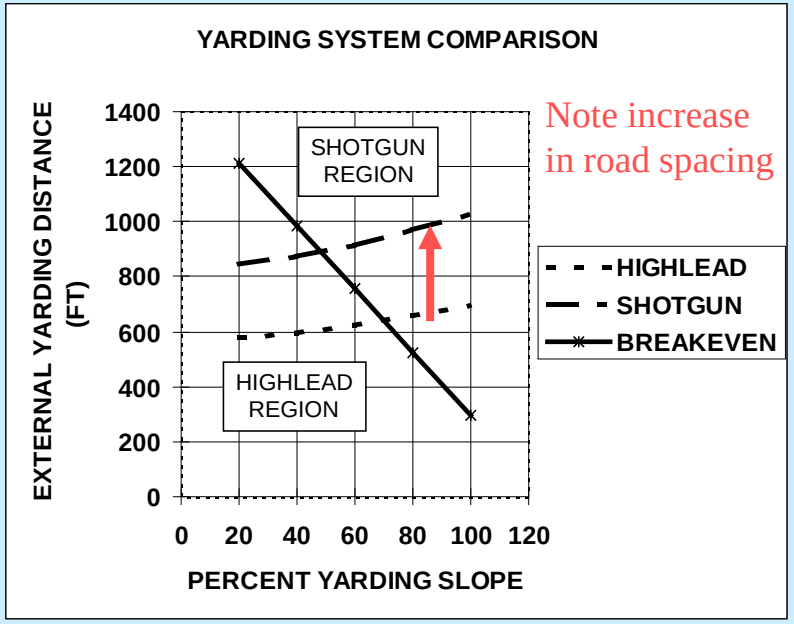
$w^* \downarrow$

Cable Yarder Configuration Impact

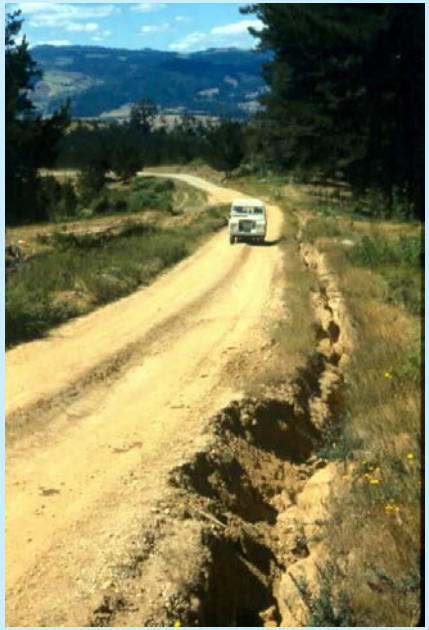








Environmental Impact



The cost of soil erosion and water pollution associated with roads should be included in their total cost - including these costs would decrease the amount of road built (spacing between roads would increase).

w*↑

Other Management Activities Impact

The cost of forest access for other management purposes should be considered in the road spacing decision.

$w^* \downarrow$

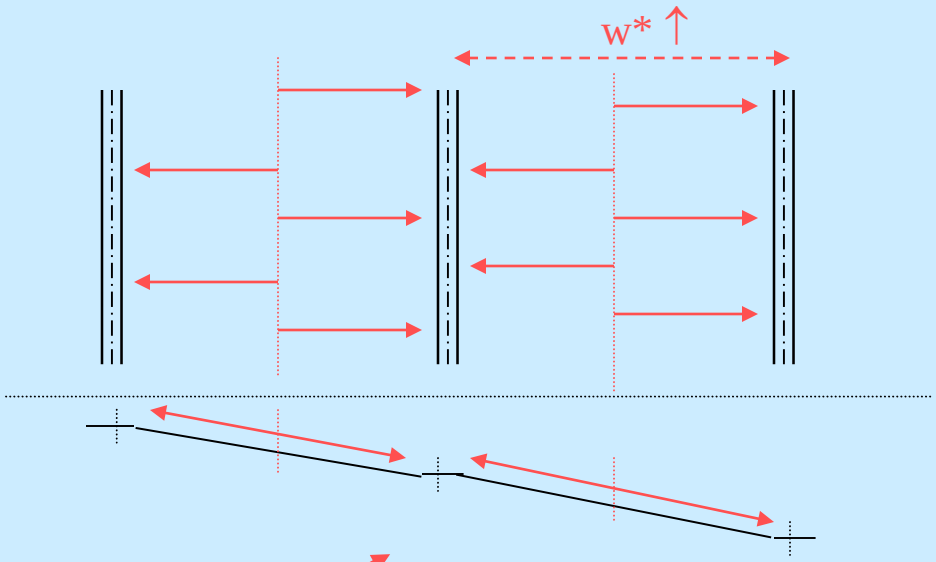
Planting

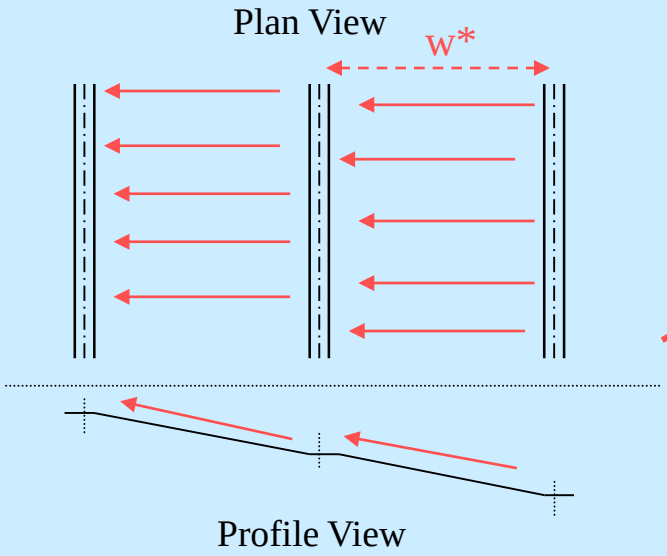
Salvage

Pruning

Yarding Pattern Impact

Yarding to a continuous landing along the road illustrated on sloping terrain.



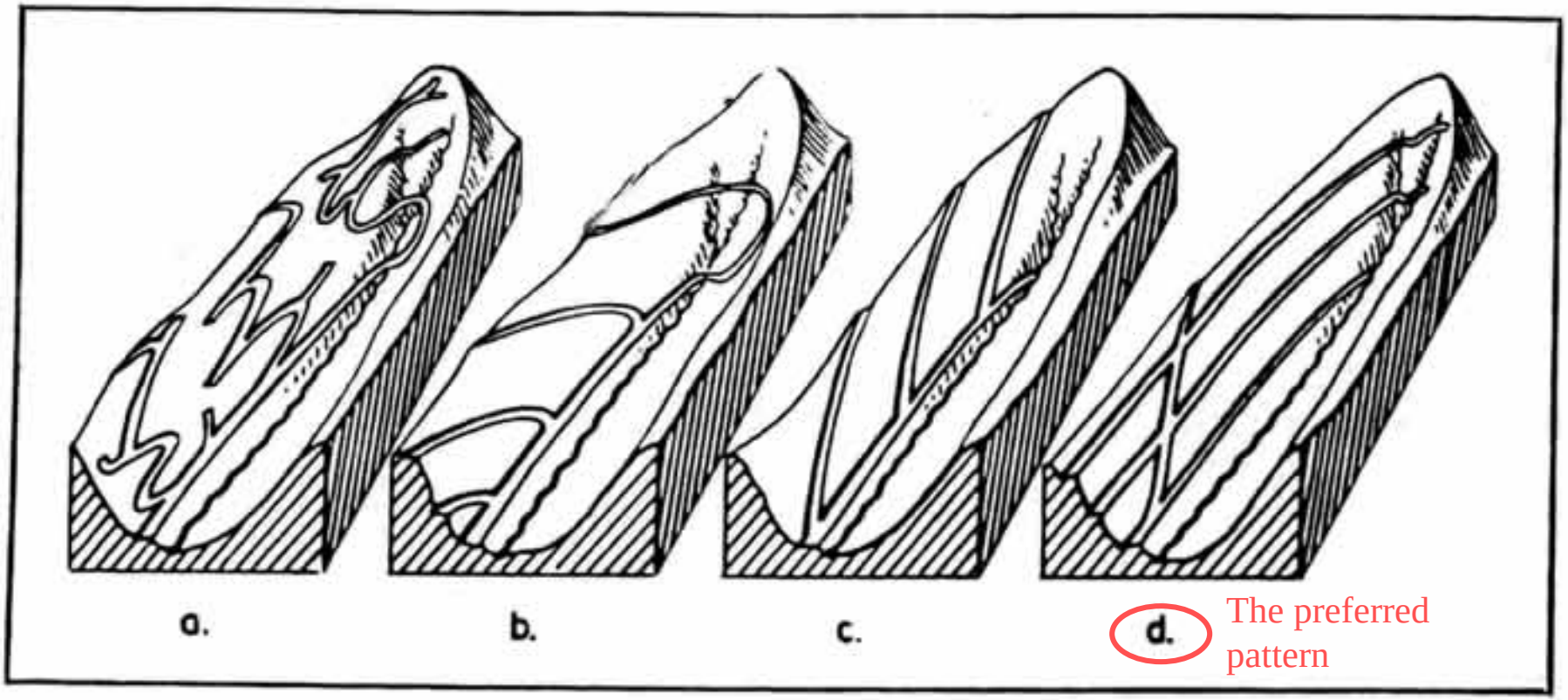


Distance between roads increases

The road spacing for two-way yarding is much farther apart compared to one-way yarding.

Analysis - Terrain Constrained Patterns

Location Principle: “Reduce the number of roads that climb between levels and increase the proportion of the drainage served by road levels spaced at the economic interval”.[1]



Four road patterns: A—Random development; B—Switchbacks at regular intervals from lowest road; C—Regularly spaced roads climbing in direction of lowest road; D—Single climbing road with others on levels roughly parallel to valley bottom road.

[1] Silen, Roy R. 1955. “More efficient road patterns for a Douglas-fir Drainage”.

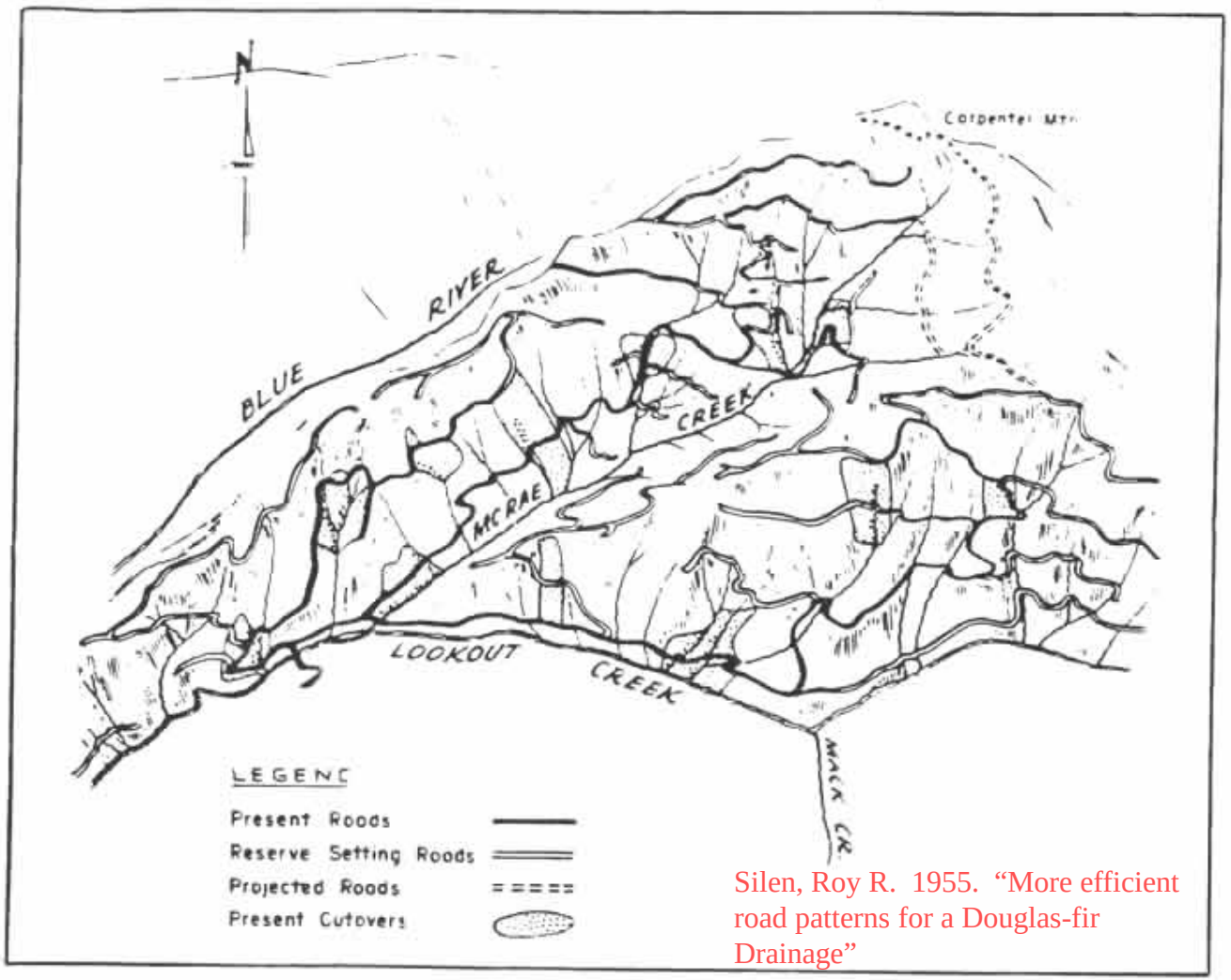
Practical Layout - Satisficing[1]

Planning Steps:[2]

Identify possible landings with their economic yarding distance on the map.

Determine which landings can be reached by truck road of the specified standard.

Identify a systematic pattern of roads that connects the landings.



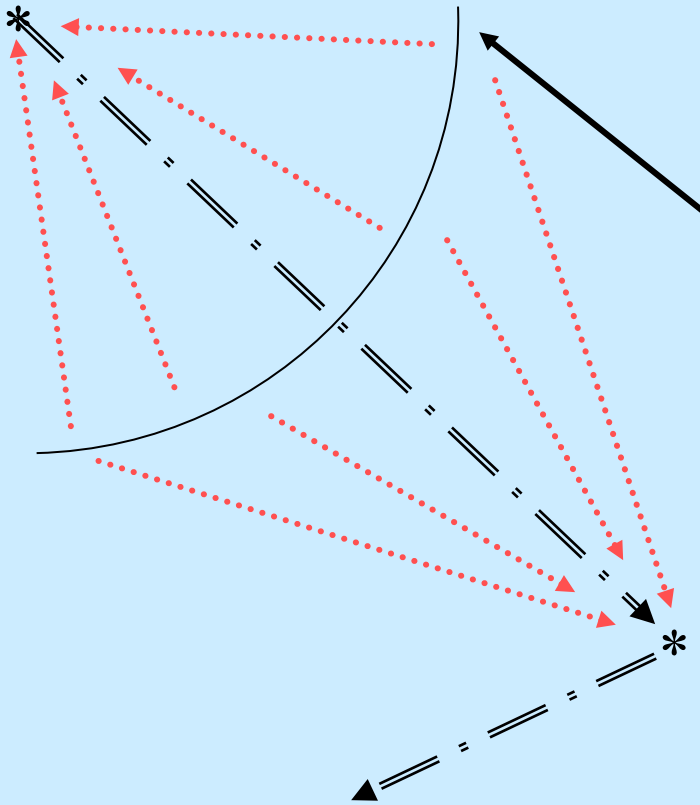
Silen, Roy R. 1955. "More efficient road patterns for a Douglas-fir Drainage"

Systematic road pattern was used on north side of Lookout Creek. Road levels are distinct, climbing road minimized. Road density is reduced, yarding improved.

[1] To obtain an outcome that is good enough. Simon, Herbert A. 1957. *Models of Man.*

[2] After Pearce, J.K. 1960. Forest Engineering Handbook.

Possible Research Topics



Optimal shape of the boundary between two settings given different yarding (total transportation) costs at each.

See: Launhardt, Wilhelm. 1900-02. The Theory of the Trace: Being a Discussion of the Principles of Location. 2 v. in 1: pt. 1. The Commercial Trace, 1900. pt. 2. The Technical Tracing of Railways, 1902. A. Bewley, Trans. Lawrence Asylum Press, Mount Road, Madras, India.

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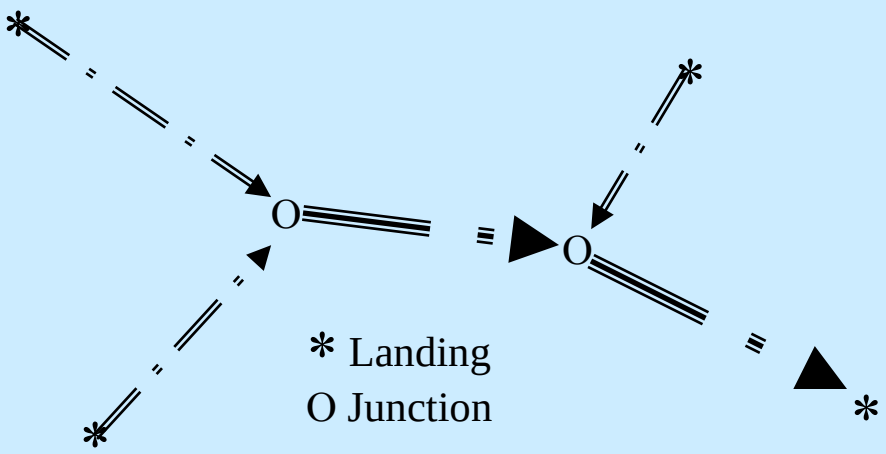

Optimal location of road junctions using multiple junctions and varying road standards.

See: Greulich, F.E. 1999. “The barycentric coordinates solution to the optimal road junction problem”. J. For. Engrg. 10(1):111-114; 10(2):81.

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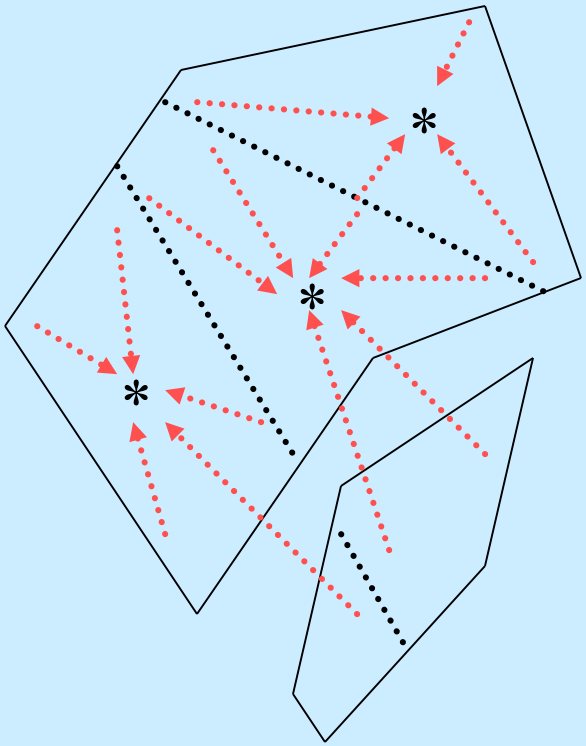

Global optimization using multiple settings on a non-convex harvest area.

See: Okabe, Atsuyuki, Barry Boots, Kokichi Sugihara and Sung Nok Chiu. 2000. Spatial Tessellations: Concepts and Applications of Veronoi Diagrams. John Wiley & Sons, New York, N.Y. 671 p.

Network Design in Forestry

- has a long history of theoretical development;
- has provided practical design rules;
- and continues to provide good research opportunities.