Session 2
Paper (d)

NETWORK PLANNING

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ABSTRACT

Harvesting of wood from the stump and transportation to the point of utilisation is usually possible by several alternative methods and routes. A manager is faced with selecting the best method and route that meets his criteria for performance. When the number of alternatives becomes large it is difficult to evaluate these without a systems approach. Network planning provides an analytical tool to enable the modelling of complex decision situations so that optimum solutions can be found. With the use of a microcomputer and suitable software this method can be quickly applied to solving problems.

ALTERNATIVES IN HARVESTING

In designing a system to move wood from the stump to the point of utilisation, a manager has available a wide range of technology and alternative ways of doing things.

The nature of the country may dictate whether ground based or cable logging is used but there may be several possibilities of machine type and configuration that could be used on a particular site.

There may be several road routes that are possible or there may be the options of constructing a road at a high or low standard, or with various maximum grade limits.

There may be a possibility of using rail or barging in the transportation network, or combinations of these. There may also be alternatives as to which mills or points of sale to supply from a particular site.

MANUAL APPROACH

The traditional approach, when faced with two alternative plans, is to prepare an estimate of cost for each, either in terms of net present cost, or rate of return on capital invested. The amount of calculation necessary to estimate the cost for various alternatives increases exponentially as the number of alternatives increases. In forest harvesting, the problem very quickly becomes complex once several harvesting methods, harveting periods, alternative transportation routes and various product types and values are to be evaluated.

A manager when faced with such a complex set of alternatives, usually takes one of two approaches. He may select the optimum solution for each independant part of the system, for example he may seek the best market and the best harvesting method, and then find the best roading system that suits that harvesting method and market, and then choose the best transport vehicle that suits the rest of the system.

A less energetic or more experienced manager may rely on his experience and intuition as to which methods will provide the lowest cost system for moving wood from stump to market.

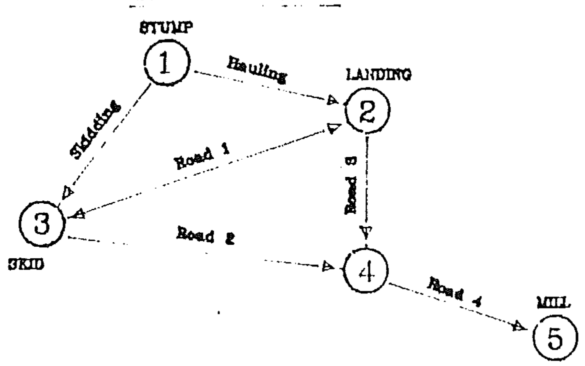
The solution obtained by these methods is usually acceptable but may be far from the optimum. A system developed by selecting the lowest cost alternative for each component, may not necessarily yeild the system with the lowest overall cost. Considerable savings may be possible if an optimum or near optimum overall solution could be found as a result of considering all parts of the system and there interation as a complete system.

NETWORKS

A network is simply a method of representing in a model the alternatives that are available in a harvesting system. A network is constructed from nodes and links. In simple terms, a node can represent a location or a particular point in a processing cycle. A link is the path that the wood flows along to get from one location to another or from one stage of processing to another.

It is reasonably easy to see how a harvesting system can be modelled using a series of nodes and links. For example the stump node is linked to a landing node with a link representing one type harvesting (ie hauling from stump to ridgetop). If an alternative harvesting method to a different landing is possible (ie tractor skidding to the valley), it can be represented by another link. The roading network can be represented by road links between intersection nodes.

SIMPLE NETWORK



The flow of wood over a link involves a cost. It is useful to consider this in two components, the fixed part of the cost, and the variable part of the cost. For a road link, the fixed cost will be the initial construction cost or upgrading cost. For a harvesting link the fixed cost is the cost of bringing the hauler or skidder to the site and its setup cost.

The variable cost is the cost of running the hauler for a haulage link or the cost of running a truck and the cost of maintaining the road, for a road link. The variable cost is usually expressed as an cost per cubic metre of wood that passes over the link.

The whole system from stump to mill or port can be modelled as a series of nodes and links representing all the various alternative harvesting methods, roading networks and utilisation points.

All that remains is to model the initial wood input and the destinations. These can be represented by recording for each volume and year, the node at which the volume enters the network and the node through which it must leave.

This completes the network and enables a large amount of information to be represented in a single model.

ANALYSIS

The process of assembling a network in itself leads to a better underatanding of alternatives and may encourage the evaluation of less obvious solutions.

There are several algorithims that have been developed for finding optimum solutions to networks assembled as described above. These typically use a linear programming method to iteratively find the shortest path through the network.

It is not necessary for a manager to understand the actual process that is used to find the optimum solution, provided he knows the criteria that the model uses to define the optimum solution. This normally is the minimum net present worth of cost for the whole system at a given discount rate.

The optimum solution is indicated as the pathway through the network for each voulme input and output. The analysis results usually in the form of a flow path list of nodes and a list of the total flow on each link.

HANDLING SPECIFIC PROBLEMS

The question of what standard of road to build arises often. There are analysis methods available that enable an experienced technician to estimate construction costs and transportation costs for various road standards and transportation type. If these costs are estimated for several options of road standard, each option can be entered into the network model as a separate link between nodes having the appropriate fixed and variable cost for that option. The analysis will select the best option when is finds the path having the lowest cost for the whole system.

It may be required to determine which mill can be supplied at the lowest cost. If several mills are possibilities, these can be linked by dummy links to a dummy node in the network model. The volume is then noted as leaving the network from the dummy node, thus leaving the analysis to find which mill lies of the least cost path.

If different revenues are available at different mills, these can be shown as negative variable costs on the dummy links. This will produce the maximum net revenue path when the model is run.

Most harvesting produces multiple product types. These various products can be modeled as separate inputs and outputs in the same model by using separate stump and mill nodes for each product type. This provides a means of finding the overall lowest cost system for all product types.

CONCLUSION

Network planning and analysis provides a powerful method of evaluating the many alternatives available to the designer of a harvesting system. Through the use of a microcomputer and suitable software, quite complex systems can be analysed at reasonably low cost.

Network analysis is a tool to model the fixed and variable costs of a harvesting system. It is an aid to management decision making and does not replace judgement or experience. Other factors not included in the model may be factors in the decision of final system selected. Network planning does however provide a means of evaluating complex alternatives on a cost basis, which would otherwise have been ignored or simplified.

EXAMPLE OF NETWORK DATA AND ANALYSIS RESULTS

LINK FILE

From node #	To node #	Variable cost	Fixed cost
1	7	2.300	40000
2	7	1.800	10000
3	7	1.200	15000
3	8	0.700	25000
7	8	2.200	40000
7	14	12.500	200000
8	9	2.500	250000
9	13	8.500	
9	23	15.000	
13	14	2.500	250000
13	15	2.000	300000
14	15	2.500	
14	17	24.000	
14	20	22.000	
15	18	14.000	
17	19	1.500	
17	28	28.000	
18	19	1.500	
18	28	19.000	
23	24	1.500	100000
23	25	1.500	100000
24	28	12.000	
25	28	10.000	

SALE FILE

Sale	Mill	Vol	Year
1	28	80000.0	0.0
2	28	40000.0	0.0
3	19	40000.0	0.0

ANALYSIS RESULTS

Volume	Year	Coef	Path
80000.0	0.0	37.80	1-7-8-9-23-25-28
40000.0	0.0	39.53	3-7-14-15-18-19
40000.0	0.0	33.25	2-7-8-9-23-25-28

Discount rate = 10.0%
Total volume = 160000.00
Total Variable Costs (Disc) = 5268000.00 (32.92 $/Unit)
Total Fixed Costs (Disc) = 818835.00 (5.12 $/Unit)
Total Variable + Fixed Costs = 6086835.00 (38.04 $/Unit)

EXAMPLE OF COMPLEX NETWORK