Using transloading times in determining the effect of reduced road standards on the delivered cost of timber

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Abstract:
In the coastal region of Norway, large volumes of relatively inaccessible plantation timber are maturing for harvest. The economic feasibility of accessing much of this timber has limited the level of harvesting activity considerably. Harvesting planners are faced with the classic dilemma of finding the appropriate level of investment in infrastructure, as against inoptimal transportation. In this paper, we present results from a simple deterministic simulation carried out to illustrate the efficiency frontiers of three transport methods, one of which requires a substantial investment in road upgrading. Results depend on assumptions made, but clearly show that in these conditions, upgrading roads for truck+trailer transport should be evaluated on a cases by case basis. Forest road length and condition, public road distance to conversion site, and investment level all play important roles in the decision structure. In the coastal regions, road upgrades would generally need to be justified by benefits other than timber harvesting alone.

Keywords: road planning, delivered cost, timber transport

1 Introduction

In Norway, less than 40% of the sustainable annual cut is harvested, significantly less than the neighbouring countries of Sweden and Finland. The low level of activity can partly be ascribed to the very limited degree of access to the forest resource in many parts of the country. Especially in the western parts, which are characterised by steep and rugged terrain, road densities can be as low as 3-8 m ha^{-1} instead of the suggested 30 m ha^{-1} needed for rational operations in similar terrain. Around 40% of the harvestable volume is located in such areas (approx. 100 million m^3). The number of roads built or upgraded in Norway decreased by 60% in the period 1998-2008, due mainly to the infeasibility of investment.

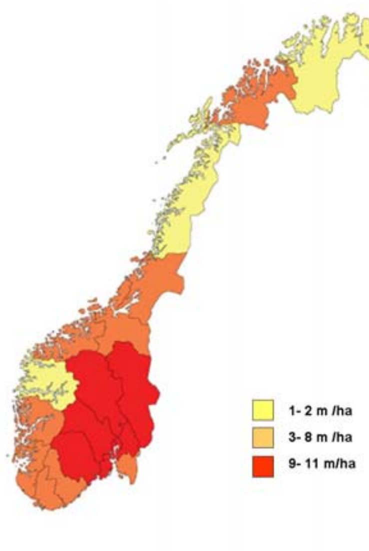

Figure 1: Forest road densities in Norway, excluding public roads. (Anon., 2011)

Road construction and maintenance cost demand a significant part of the forest management budget, and efforts to minimise these have long been an important research topic. Funds spent on forest roads should be justified by the improved economics of harvesting and transport, although there are often other beneficiaries of forest roads (Steinmüller, 2003). The complexity of the problem of finding the optimal investment level lends itself to Operations Research (OR) methods. Costs can also be reduced through optimal road alignment techniques where both absolute methods (Akay, 2006), and heuristics (Tan, 1999, Aruga et al., 2005) have been used successfully. However, fewer studies consider the combined delivered cost of timber, i.e. the combination of construction, maintenance, and transport. Olsson & Lohmander (2005) illustrated the use of mixed-integer programming in a detailed model for a region over a 10 year planning period. Their model matches harvesting areas with seasons in minimizing the sum of harvesting costs and the sum of road investments. Stückelberger et al. (2006) present a model that estimates spatial variability in road life-cycle costs, assisting in selecting road lines likely to have the lowest combined construction and maintenance costs. Pulkki (1996) used Network Analysis to study the impact of reduced investment in forest roads (reducing the number of water crossings) on hauling costs. In Norway, Lileng and Haartveit (2004) use the ‘total cost approach’ in studying the viability and trade-offs between a road construction project and transport costs. That approach includes the trade-off between terrain transport (extraction), road transport, and road investment.

1.1 Aim

In this study, we try to determine good intersection points between form of timber transport (truck or truck-trailer) and the level of investment in the road infrastructure. Transloading from truck to trailer at the forest gate is a common practice in these conditions, and a pivot point between the two forms of transport. A time study of that process forms the basis of the analysis.

2 Material and methods

A study was done to investigate the consequences of constructing new roads to a minimum acceptable standard - defined as Class 5 in the Norwegian classification system. In theory, this involved reducing the width to 4m, decreasing the minimal horizontal curve radius to 10m, the minimal vertical curves to 60m and 100m (troughs and tops respectively) and increasing the maximum allowable incline to 20%. These road standards prohibit the use of timber trailers, so the volume per truckload is constrained. In the model, the reduced road standard is simply represented by a lower construction / upgrading cost.

2.1 Road construction costs

Road construction costs are taken directly from Statistics Norway (Anon.,2011). They represent the mean weighted cost between roads constructed with public subsidy and those constructed with private funds. In simplification, the road classes are simply divided into 'high grade' roads (suitable for timber trucks with trailers to traverse at high speed) and 'low grade' roads, suitable only for timber trucks without trailers (fig.2). The initial cost of a high grade road is approximately double that of a low grade road.

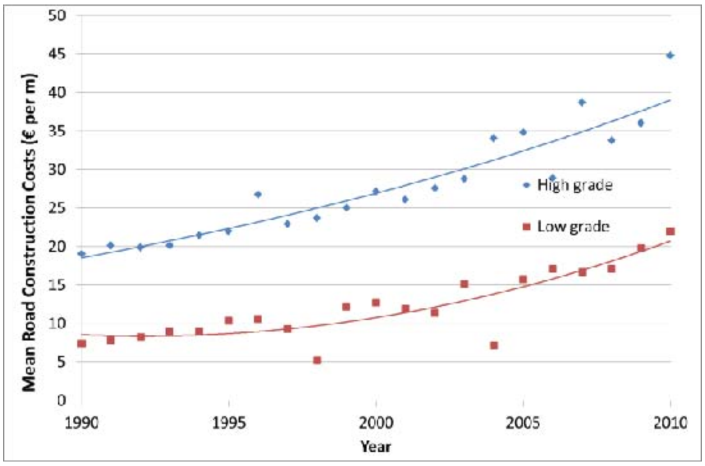

Figure 2: Mean road construction costs for low and high grade roads over a 20 year period.

2.2 Transloading

Normal practice when trailers cannot be taken into the forest road network is to transload timber from the truck to the trailer, then to fetch another load, hook up the trailer and drive to the plant. For this, the transport operator is paid a premium. A time study of 10 transloading repetitions was done at an actual operating site. This included manoeuvring the truck into position, preparation and transloading. Mean transloading time as 13.5 min. per load, with a standard deviation of 2.5 minutes. Of this, actual loading time was 6.4 min. per load. Trailer hooking time was not measured separately.

2.3 Truck transport

We presume that fresh timber is being transported. The truck capacity is set at 15m^3 on the load to be transloaded (travels on forest road only), and 13 m^3 on the load for public road transport. This means that the entire truck is only carrying 28 m^{3,} while full load capacity is roughly 36 m^3. The reason for this is that transport in the coastal region is often limited by the design specifications of the bridges, which have axle and total load restrictions somewhat below national norms. Road quality influences driving speed, which together with distance makes up turnaround time.

2.4 Economic assumptions

All economic assumptions were based on a recent cost model for freight and logistics developed by the Norwegian Institute of Transport Economics (Grønland, 2011). This model includes calculations of time, operating and terminal costs and covers timber transport specifically (table 1). It was also assumed that a transport operator owned and incurred costs for a full rig (truck and trailer) irrespective of whether the trailer was used on specific occasions or not.

Table 1: Vehicle ownership and operating costs (timber truck and trailer)

Detail	Cost
Purchase price (€)	291 391.00
Fixed cost (€ h^{-1})	67.82

Operating cost (€ km^{-1})	0.74
Terminal cost (€ ton^{-1})	3.44
Truck capacity (tons)	34

2.5 Simulation

A deterministic simulation was made in the SAS programme. The simulation ran a range of available harvesting volumes against forest road distances and public road distances to terminal. Numerous assumptions on travel speeds, load sizes and distributions had to be made, using input from local transport organisations where possible. Three transport scenarios were considered:

1. Low grade road -> transport with rigid truck from landing to public road->transload to trailer ->refill truck at landing and drive to public road twice->connect trailer and drive to final terminal (Sc1)

2. Low grade road->transport with rigid truck to final terminal (Sc2)

3. Invest in high grade road->transport with truck and trailer to final terminal (Sc3-road costs not included, Sc3x-road costs included)

3 Results and discussion

The relative performance of Scenarios 1-3 are largely determined by the forest road distance (fig. 3, A-C). The breakeven between Sc1 (transloading) and Sc2 (only rigid truck to mill) happens at about 14 km when the forest road distances is 500m. When the forest road distance is increased to 2500 m (fig. 3B) the intersection distance is doubled to almost 30 km, the cost of transloading increases significantly. At 2500m, and a public road distances of roughly 7 km, it is more economical to upgrade the road to give access to the truck+trailer (fig.3C). In this case, the rigid truck (Sc2) has an economic range of approximately 40 km as compared to upgrading the road and using the truck+trailer. Given a uniform random distribution of public road distances, the systems would perform equally well up to a maximum distance double that of the point of intersection. This is important to know for transport planners in the Norwegian fjordlands, where road distances to local quays can be quite short, though narrow and winding and difficult to negotiate with a truck-trailer. The actual cost level is dependent on the assumptions that the calculations are based on, but findings generally support normal practice which is to transload when short forest roads in poor condition are encountered, and to upgrade roads when they are longer. However, the option of using only the rigid truck appears to have a larger economic justification than expected, and this could probably be practiced more.

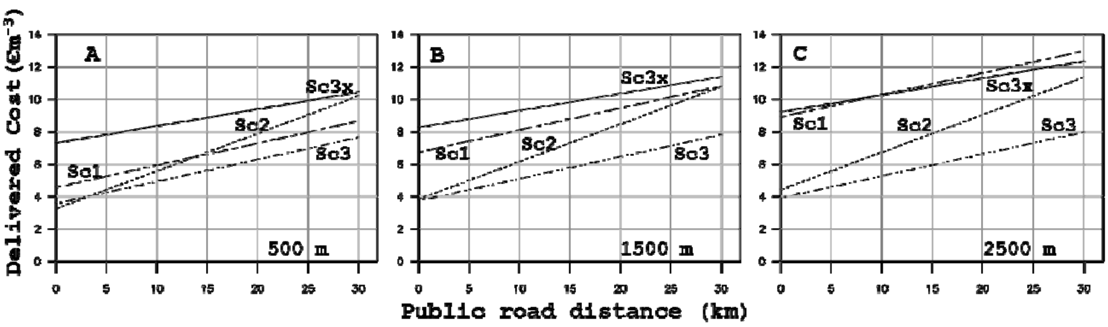

Figure 3: Intersection of delivered costs for scenarios Sc1, Sc2 and Sc3, for 3 forest road distances (A-500m, B-1500m, C-2500m).

The cost of upgrading the road (€20 m^{-1}, with a 60% subsidy), when allocated over the expected volume to come from the road within its initial service period adds a constant offset to Sc3, and is shown by the Sc3x scenario in figure 4. In this case, the assumption is that the forest road is 1000m and the volume 8000 m^3. A reduced distance and increased flow would reduce the delivered cost, while the opposite would increase it. The price level indicated by Sc3x, illustrates a classic dilemma in forest road planning - who should pay the difference to the next cheapest option. As Steinmüller (2003) points out, there are many users and functions of forest roads, and these can be quantified to varying degrees. However, many of the new plantation areas maturing for harvesting in the coastal region of Norway are located in valleys with a topography that prohibits external use and limits the benefits to improved forest management.

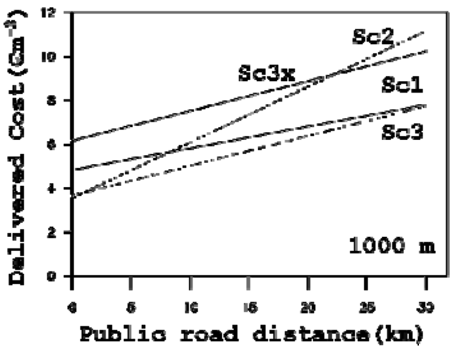

Figure 4: Intersection points for delivered costs for all 4 scenarios (assuming a forest road of 1000m and volume of 8000m^3)

4 Conclusions

In a situation like that in the coastal areas of Norway, where large volumes of plantation forest timber are coming online for harvesting for the first time, and where these stands are often small and scattered, large investments in forest infrastructure are not always justified. Considering that the public road network in these areas is often narrow and windy, with many bridges with constrained axle and total tonnage specifications, forest road planners need to critically examine the feasibility of transport solutions in each case. The deterministic simulation done in this study is merely useful in pegging out some of the corner points of feasible operating areas. The model could be improved by running it on a range of actual distributions of forest road lengths and volumes to be transported.

5 Acknowledgements

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6 References

Akay, A. (2006) Minimizing total costs of forest roads with computer-aided design model. *Sadhana*, 31(5) 621-633.

Anon. 2011. Forestry Statistics. Statistics Norway (In Norwegian). Available at http://www.ssb.no/emner/10/04/20/ (accessed Sept. 2011).

Aruga, K., Sessions, J. & Miyata, E. S. (2005) Forest road design with soil sediment evaluation using a high-resolution DEM. *Journal of Forest Research*, 10(6) 471-479.

Grønland, S. E. (2011) Cost models for freight and logistics. *TØI rapport*. Oslo, Institute of Transport Economics. ISSN 0808-1190.43pp.

Lileng, J. K. & Haartveit, E. Y. (2004) Differentiation of road standards using the total cost approach to improve conditions for log supply. In *NSR Conference on Forest Operations 2004.* Hyytiälä Forest Field Station, Finland, Silva Carelica 45 201-207.

Olsson, L. & Lohmander, P. (2005) Optimal forest transportation with respect to road investments. *Forest Policy and Economics,* 7(3) 369-379.

Pulkki, R. (1996) Water Crossings Versus Transport Cost: A Network Analysis Case Study. *International Journal of Forest Engineering,* 7(2) 59-64.

Steinmüller, T. (2003) Evaluation of the Social and Economic Benefits of Subsidized Forest Road Developments in Austria. In Limbeck-Lilienau, Steinmüller, T. & Stampfer, K. (Eds.) *High Tech Forest Operations for Mountainous Terrain.* Schlaegl, Austria.

Stückelberger, J. A., Heinimann, H. & Burlet, E. (2006) Modeling spatial variability in the life-cycle costs of low-volume forest roads. *European Journal of Forest Research,* 125(4) 377-390.

Tan, J. (1999) Locating forest roads by a spatial and heuristic procedure using microcomputers. International Journal of Forest Engineering 10(2) 91-99