

Evaluating the efficiency of the Swiss forest road network for timber harvesting and transport



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Introduction

Timber transportation is an important cost factor for wood production in Switzerland. Hauling distances, road transport distances, and the number of necessary trips all depend on road density and the spatial distribution of forest roads, as well as on the road dimensions (width, carrying capability).

In the Swiss National Forest Inventory NFI (see box), information about forest roads has been recorded for more than 30 years. Roads are included in the survey if they have a minimum transport capacity of a 10-ton axle load and minimum width of 2.5 m. In the latest survey, also roads connecting forest roads to main (usually cantonal) roads were mapped.

This study aims at evaluating the efficiency of the Swiss forest road network for wood transport, taking into account the varying suitability of roads for carrying vehicles of different sizes.

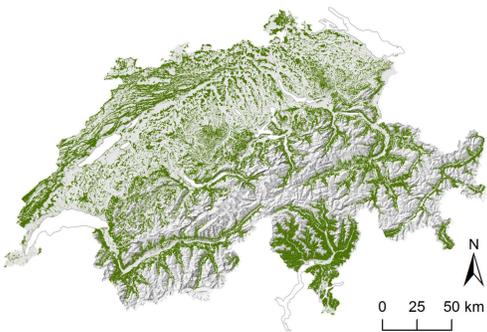


Figure 1: Topography and forested areas in Switzerland (source: swisstopo / NFI).

The Swiss National Forest Inventory NFI

The NFI records the current state and changes of the Swiss forest. Data are collected using remote sensing, field surveys at ca. 6500 sample plots and enquiries at the local forest services. The NFI is a collaboration of the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) and the Forest Division at the Federal Office for the Environment (FOEN). The first survey started in 1983.

Method

Based on the road attributes from the previous survey (2004-2006), all changes to the road network were mapped on paper. Using geometries from the swissTLM3D road dataset, the mapped information was then digitised by filling the roads' attribute fields.

The new road dataset was used to build a topological network, from which network connectivity and distances could be computed.

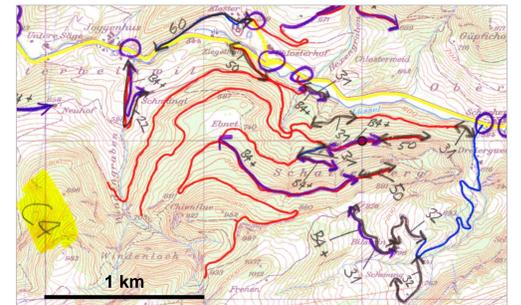
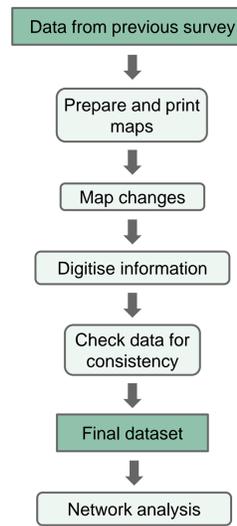


Figure 2: Extract from a map before digitisation.

Road category	Width	Largest vehicle allowed
Basic	≥ 2.5 m	10 t axle load (~20 t)
A	≥ 3.5 m	3-axle, 26 t vehicle
B	≥ 3.5 m	4-axle, 28 t / 32 t vehicle
C	≥ 3.5 m	5- / 6-axle, 40 / 44 t vehicle

Table 1: Main forest road categories mapped in the NFI (2013-2014).

Results

Study area

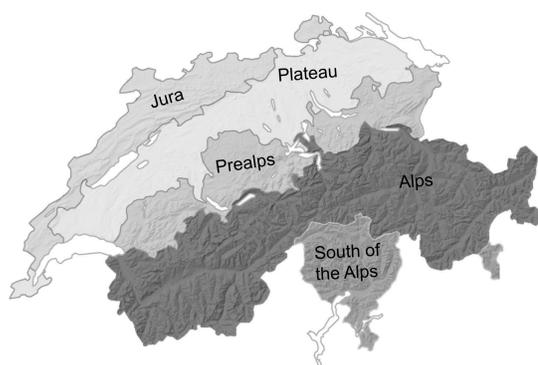


Figure 3: Classification of the country into wood production regions according to growth and wood production conditions, as defined in the NFI.

Forest road categories

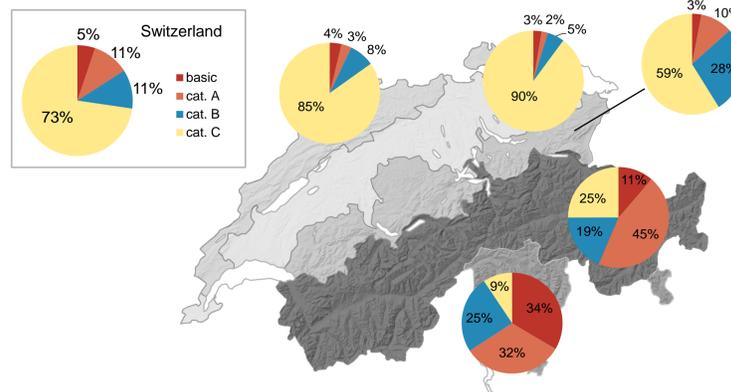


Figure 4: Proportion of each road category compared to the total forest road length. The predominant forest road category varies strongly between wood production regions in Switzerland. Roads for heavy vehicles are found mainly in areas of low and moderate relief.

Variability of forest road density

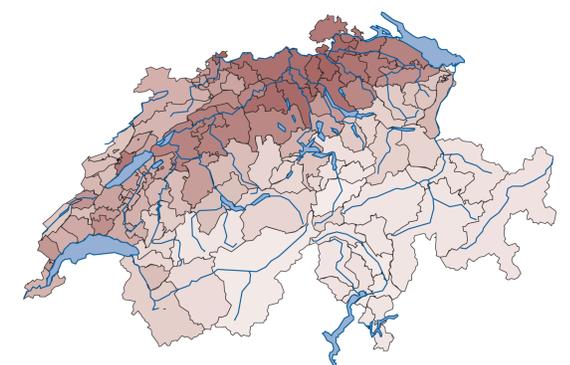


Figure 5: Road density (road length by forest area) for forest roads at least 3 m wide and with a carrying capability of min. 28 t (4-axle vehicles), by forest district. Densities increase from light red (0 m/ha) to dark red (84 m/ha) (Brändli et al. 2016).

Straight-line distance from sampling points to nearest road

Forest road category / vehicle type	Distance to nearest forest road	Jura	Plateau	Prealps	Alps	South of the Alps	Switzerland
Width ≥ 2.5 m / 2 axles, 20 t or larger	≤ 500 m	98	97	84	72	44	80
	> 500 m	2	3	16	28	56	20
Width ≥ 3.0 m / 4 axles, 28 t or larger	≤ 500 m	94	96	72	36	22	63
	> 500 m	6	4	28	64	78	37

Table 2: Percentage of sampling points within a given distance from the nearest forest road, by production region. In the "Alps" and "South of the Alps" regions, a higher-than-average percentage of points lies more than 500 m from the nearest road.

Network distances

Road category	Mean straight-line distance to road	Plots not connected to main road	Mean network distance to main road
Basic	0.3 km	7 %	3.0 km
A	0.4 km	7 %	2.9 km
B	0.4 km	30 %	2.6 km
C	1.6 km	10 %	2.1 km

Table 3: Distances between sample plots and the nearest road; percentage of plots where nearest road is not connected with main road network on the road type specified; and network distance to the main road network.

Ongoing research

We currently...

- test the use of more realistic methods to find the most probable location on a road where wood is transferred to trucks, taking topography and other factors into account
- work on a spatially explicit approach to analyse the efficiency of the road network for the entire Swiss forest

References

- Brändli, U.-B. (ed.) 2010. Schweizerisches Landesforstinventar. Ergebnisse der dritten Erhebung 2004–2006, Birmensdorf, Eidgenössische Forschungsanstalt für Wald, Schnee und Landschaft WSL. Bern, Bundesamt für Umwelt, BAFU.
- Brändli, U.-B., Fischer, C. & Camin, P. 2016: Stand der Walderschliessung mit Lastwagenstrassen in der Schweiz. Schweizerische Zeitschrift für Forstwesen, 167 / 3, 143-151.
- Müller, K., Fraefel, M., Cioldi, F., Camin, P. & Fischer, C. 2016: Der Datensatz "Walderschliessungsstrassen 2013" des Schweizerischen Landesforstinventars. Schweizerische Zeitschrift für Forstwesen, 167 / 3, 136-142.
- swisstopo data: Reproduced by permission of swisstopo (JA100118)