3.5 Expenditure for Timber Felling and Extraction

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3.5.1 Introduction

The expenditure for the Timber Felling and Extraction is a measure of the availability of timber. It is derived (modeled) for the total timber volume in the Swiss forest using a uniform method.

For each of the sample points the objectives were to:
- Determine the timber harvesting method actually being used
- Estimate the corresponding expenditure for the timber felling and extraction
- Convert the calculated work expenditure into Swiss Francs

The input variables for the model result from interviews at the forest service, as well as from the terrain, stand, and tree data in the terrestrial inventory (see Chapter 2.3, Terrestrial Inventory). The model is based as much as possible on work published about expenditure calculation and does not account for regional conditions or the actual timber market situation. The expenditure for the timber harvest was used for timber production considerations, e.g., for the exploitation potential or management scenarios (see Chapter 3.3 Prognosis and Management Scenario).

3.5.2 Methods

The process of the timber harvest is comprised of felling and extraction. During the felling the tree is felled and trimmed (i.e., delimbed and divided into assortments). During the extraction the timber is brought from the felling point to the forest road where it is stored and sold either as a complete tree or in the form of the assortments. For each of the sample points the expenditure for timber felling and extraction is derived from the terrain, stand, and tree data, as well as the information from the timber harvest that was gathered during the interview with the forest service.

The extraction process is divided into separate stages of work (STIERLIN *et al.* 1994). For the individual stages, the corresponding extraction expenditure was calculated (unit: min/m^3) using information about the timber extraction method and logging distance. The total extraction expenditure is the sum of all expenditures of the individual extraction phase. The total timber harvest expenditure is the sum of timber felling and extraction expenditures. In order to compare different procedures the expenditure was converted from minutes into Swiss Francs (unit: Fr./m^3) with the help of system cost rates.

Input variables for the model to determine the timber harvest expenditure are:
- Stand and tree data (e.g., tree species, tree dimensions, timber volume, assortment volume, mean volume per piece)
- Terrain data (e.g., slope)
- Timber harvest data (e.g., type of timber harvest, timber extraction method, logging distance)

Since the assessment of the timber harvest data was not primarily designed for the calculation of the expenditure several limitations apply:
- The survey did not consider the overall timber harvest concepts or methods, but considered instead the individual steps of the process. Since the timber harvest is becoming an increasingly complex system, the expenditure or the cost of the entire timber harvest process is sometimes reflected inaccurately by the sum of the expenditures or the cost of all of the individual process steps.

– For individual timber extraction methods (e.g., helicopter), important factors of influence are unknown. For the expenditure calculation, these unknown factors had to be replaced with assumptions.
– For certain timber extraction methods no valid model was available (e.g., train, boat). Since they only applied to a very small number of cases (approximately 70 out of 9,400 mentioned), an overall rate is used for the expenditure estimation.
– The amount of timber and the assortment distribution resulting from an actual harvest is unknown. The data was, therefore, determined from all trees measured on the sample plot using volume and assortment tariffs.
– When comparing the two inventories NFI1 and NFI2, it must be considered that the retrieval of the extraction data was based on different definitions.

The calculated expenditure of the timber harvest does not reflect the true cost that would incur for the exploitation of a sample plot. Several expenditures such as marking timber, slash removal, or additional expenditures for a thinning are not considered. The expenditures modeled are, therefore, not a basis for a timber harvest calculation.

The interview with the forest service included the last treatment on the sample plot since the first NFI survey (i.e., the last ten years). If no harvest took place, the most probable harvesting method, according to the forest service, was described. The timber harvest processes recorded in this way are not necessarily the most inexpensive ones and should therefore not be considered to be the best possible timber harvesting method for the sample plots. Furthermore, some of the references used as a basis for the calculation are not very recent; because of increases in productivity, this leads to an overestimating of the expenditures.

3.5.3 Employed Sources (Models used)

The timber harvest expenditure is calculated for the timber felling and for its extraction in 99% and 78% of the cases, respectively, with the forest enterprise simulation model FBSM (ERNI and LEMM 1995). The FBSM covers the following cases:
– Timber felling with chain saw
– Hand-skidding
– Extraction with tractor
– Extraction with conventional cable-crane and mobile cable-crane

For the expenditure calculation of the processor, harvester, forwarder, and helicopter, all rates used are all inclusive. They are based on the nomogram design (SCHWEIZER 1996) being transformed into calculation procedures.

(Note: Since at the time of the attribute derivation, the publication by SCHWEIZER (1997) was not yet available, the draft (SCHWEIZER 1996) was used in its place. This draft differs in some points from the final version. In particular, the nomograms being used to determine the necessary time were slightly modified. As a consequence, this resulted in expenditure differences for the processor, harvester, and forwarder in the order of ±10%. For the helicopter, the expenditures were underestimated as compared with the final version by approximately 20%.)

Several different sources are used for the derivation of the expenditure for the remaining harvesting methods.

3.5.4 The Derived Variables for the Individual Working Equipment

Table 1. Timber felling (felling and trimming of the tree).

Working equipment:	**Chain saw** (including axe)	
Input variables:	Mean basal area diameter dg (cm), slope, type of timber (coniferous/broadleaf)	
Derivation of the expenditure:	FBSM (p. 84, ERNI and LEMM 1995)	
	Source: (PFEIFFER 1993)	
Cost rate:	Logger (FW):	40.– Fr./h (WVS 1995a)
	Chain saw (MS):	12.– Fr./h (SCHWEIZER 1997)
	System cost rate:	0.85 Fr./min (1FW+1MS)
Working equipment:	**Processor**	
Input variables:	Mean volume M (Efm)	
Derivation of the expenditure:	Expenditure (min/m^3)=e $^{0.6476-0.6604*\ln(M)}$	
	Source: (Fig. N, SCHWEIZER 1996)	
Cost rate:	Processor (P):	263.– Fr./h (VSFU 1995)
	Specialist (S):	43.50 Fr./h (WVS 1995a)
	System cost rate:	5.10 Fr./min (1P+1S)
Working equipment:	**Harvester**	
Input variables:	Mean volume M (Efm)	
Derivation of the expenditure:	Expenditure (min/m^3)=e $^{0.9049-0.6653*\ln(M)}$	
	Source: (Fig. E, SCHWEIZER 1996)	
Cost rate:	Harvester small (VEk):	145.– Fr./h (VSFU 1995)
	Harvester large (VEg):	263.– Fr./h (VSFU 1995)
	Specialist (S):	43.50 Fr./h (WVS 1995a)
	Logger (FW):	40.– Fr./h (WVS 1995a)
	Chain saw (MS):	12.– Fr./h (SCHWEIZER 1997)
	System cost rate:	M≤0.2 m^3 without manual felling: 3.15 Fr./min (1VEk+1S) M>0.2 m^3 with manual felling: 5.95 Fr./min (1VEg+1S+1FW+1MS)

Table 2. Extraction (including preskidding).

Working equipment:	**Hand-skidding**	
Input variables:	Mean basal area diameter dg (cm), distance for timber extraction Dist (m)	
Derivation of the expenditure:	FBSM (p. 85, ERNI and LEMM 1995) Basis: (ABEGG 1980)	
Cost rate:	Logger (FW):	40.– Fr./h (WVS 1995a)
	System cost rate:	0.65 Fr./min (1FW)
Remark:	Normal conditions are assumed.	
Working equipment:	**Horse**	
Input variables:	Volume per piece St (m^3 w.B.), distance for timber extraction Dist (m)	
Derivation of the expenditure:	Expenditure (min/m^3) = 60/(St*(1.24+(1057/(Dist+33.35))))	
	Source: (KEILEN and DIEHL 1986)	
Cost rate:	Horse (Pf):	20.– Fr./h (SCHMID 1996)
	Horsemen (PfF):	40.– Fr./h (SCHMID 1996)
	System cost rate:	1.00 Fr./min (1Pf+1PfF)
Working equipment:	**Tractor** (including individual cable winch and built-in cable winch) and articulated skidder	
Input variables:	Mean volume per piece Vmit (m^3), distance for timber extraction Dist (m), slope, skidding, assortment	
Derivation of the expenditure:	FBSM (p. 85, ERNI and LEMM 1995) Basis: (ABEGG 1980; 1991)	
Cost rate:	Tractor (T):	65.60 Fr./h (forestry tractor average, 50kW, Double-drum winch (6t), radio equipment)
	Articulated Skidder (KS):	89.40 Fr./h (skidder average, 60kW, double-drum winch (8t), radio equipment)
	Machine operator (M):	41.– Fr./h
	System cost rate:	T: 1.80 Fr./min (1T+1M) KS: 2.15 Fr./min (1KS+1M)
	Source: (WVS 1995b)	
Remark:	Normal conditions are assumed for setting choker and turning.	
Working equipment:	**Forwarder** (including all-terrain crane vehicle, Unimog, and clam skidder)	
Input variables:	Volume per piece St (m^3), distance for timber extraction Dist (m)	
Derivation of the expenditure:	Dist ≤100 m: Expenditure (min/m^3)=$e^{1.3127-0.1328*\ln(St)}$ Dist >100 m: Expenditure (min/m^3)=$e^{1.3127-0.1328*\ln(St)+0.002*Dist}$ Source: (SCHWEIZER 1996) Basis: (LÜTHY 1996a)	
Cost rate:	Forwarder (F):	129.– Fr./h (VSFU 1995)
	Machine operator (M):	41.– Fr./h (WVS 1995b)
	System cost rate:	2.85 Fr./min (1F+1M)
Working equipment:	**Mobile cable-crane** (MSK)	
Input variables:	Mean volume per piece V (m^3), direction of timber transport, total timber volume	
Derivation of the expenditure:	FBSM (p. 87 ERNI and LEMM 1995) Line length L (m) =2*Dist (m) Basis: (FRUTIG and TRÜMPI 1990)	
Cost rate:	Mobile cable-crane Small (MSKk):	64.20 Fr./h (WVS 1995b)
	Mobile cable-crane Medium/large (MSKg):	140.90 Fr./h (WVS 1995b)
	Logger (FW):	40.–Fr./h (WVS 1995a)
	System cost rate:	L≤300 m: 2.60 Fr./min (0.55*MSKk+3*FW) 300<L≤600 m: 3.60 Fr./min (0.55*MSKg+3.5*FW)

Working equipment:	**Conventional cable-crane** (KSK)	
Input variables:	Mean volume per piece V (m^3), mean driving distance Dist (m), total timber volume	
Derivation of the expenditure:	FBSM [S. 87, Erni und Lemm 1995) Basis: (Abegg *et al.* 1986a, 1986b; LEMM 1991)	
Cost rate:	Conventional cable-crane (KSK):	70.– Fr./h (WVS 1995b)
	Logger (FW):	40.–Fr./h (WVS 1995a)
	System cost rate:	3.30 Fr./min (0.55*KSK+4*FW)
Remark:	The total timber volume is estimated from the line length; the line length is calculated as twice the mean driving distance.	
Working equipment:	**Helicopter**	
Input variables:	Distance for timber extraction Dist (m), tree species (coniferous/broadleaf)	
Derivation of the expenditure:	Broadleaf: Expenditure (min/m^3) = 3.2+0.00055*Dist Conifer: Expenditure (min/m^3) = 0.9*(3.2+0.00055*Dist) Source: (Fig. M, Schweizer 1996)	
Cost rate:	Helicopter small (Heli):	2040.– Fr./h (SCHWEIZER 1997))
	Logger (FW):	40.–Fr./h (WVS 1995a)
	System cost rate:	34.60 Fr./min (1*Heli+4*FW)
Remark:	Height differences are not assessed. Assumptions: ΔH=300 m, newly fallen timber	
Working equipment:	**Truck** (LKW)	
Input variables:	Expenditure (min/m^3) is not determined	
Derivation of the expenditure:	All inclusive rate:	6.00 Fr./m^3 (LÜTHY 1996b)
Cost rate:	Truck transports hardly depend on the distance for the range of distances relevant in the NFI (1–5 km).	
Working equipment:	**Forwarder** (including crane vehicle, Unimog)	
Input variables:	Distance Dist (m)	
Derivation of the expenditure:	Expenditure (min/m^3) = 1.24+0.001*Dist Source: (LÜTHY 1996a)	
Cost rate:	Forwarder (F):	129.– Fr./h (VSFU 1995)
	Machine operator (M):	41.– Fr/h (WVS 1995b)
	System cost rate:	2.85 Fr./min (1F+1M)
Remark:	To this category belongs, especially, transports with the Unimog, crane vehicles, and similar vehicles on truck accessible roads. Assumption: Transport from storage to storage.	
Working equipment:	Other type of timber extraction methods (like rafting/floating, sledge, cable railway, boat, train)	
Input variables:		
Derivation of the expenditure:	Expenditure (min/m^3) is not determined	
Cost rate:	All inclusive rate:	100.– Fr./m^3

3.5.5 Literature

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