

# Economic Impacts on the Forest Sector of Increasing Forest Biodiversity Conservation in Finland

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In the next coming years, political decisions will be made upon future actions to safeguard forest biodiversity in Southern Finland. We address the economic consequences on the Finnish forest sector of conserving additional 0.5% to 5% of the old growth forest land in Southern Finland. The impacts on supply, demand and prices of wood and forest industry production are analysed employing a partial equilibrium model of the Finnish forest sector.

An increase in conservation raises wood prices and thus the production costs of the forest industry. This makes sawnwood production fall, but does not affect paper and paperboard production. The forest owners' aggregated wood sales income is unaffected or slightly increased, because an increase in stumpage prices offsets the decrease in the harvests. If conservation increases wood imports, negative effects on forest industry become smaller whereas aggregated forest owners' income may decline depending on the magnitude of import substitution.

**Keywords** forest biodiversity conservation, roundwood market, forest industry production

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## 1 Introduction

Forest biodiversity safeguarding has been one of the most important issues internationally as well as in the Finnish national forest and environmental policies since 1990's. Finland is committed to the decisions made at the international level, e.g., in Rio de Janeiro in 1993 and Johannesburg

in 2002, while it is participating also in the current activities at a European level. The aim to enhance forest biodiversity has already led to several action- and research programs in recent years. An important program, The Forest Biodiversity program for Southern Finland (METSO, 2003–2007) is ending. METSO was established to experiment new voluntary instruments for forest

biodiversity protection. METSO ending, decisions will be made for the future biodiversity protection measures. In order to support the political decisions, information on the economic consequences of the biodiversity conservation is needed.

The present conservation area in Finland is highest in Europe (Parviainen and Frank, 2003). Protected forests cover about 13.9% from the forestry land area (Finnish Statistical Yearbook of Forestry 2006, p. 90–91), but geographical allocation is skewed. The main part of the most valuable biotopes exists in the forests of Southern Finland with 2.2% of the forestry land conserved. The status of forest biodiversity protection in the South has been considered unsatisfactory (Ministry of the Environment, 2000), and raising conserved forest area up to 10% has been called for (Hanski 2003). Studies on the valuation of the benefits associated with the forest conservation (e.g., Pouta 2003, Lehtonen et al. 2003, Horne et al. 2004, p. 39) indicate that the Finnish citizens have willingness to pay for the increased forest biodiversity protection.

The increase in forest conservation is not necessarily without problems, because the Finnish economy and welfare of the citizens are rather dependent on the economic use of forest resources. Stumpage income and employment opportunities in the forest sector are important especially for rural people. Furthermore, the forest industry exports account for about 20% of total export income of Finland.

The previous Finnish results obtained from econometric studies indicate that setting aside forests for conservation increases stumpage prices, reduces wood harvests and leads to a rise in production costs of the forest industry (e.g., Leppänen et al. 2000, p. 70, Leppänen et al. 2005, Linden and Uusivuori 2002). Linden and Uusivuori (2002) suggest that negative short-run effects of conservation on commercial roundwood stock will be partly compensated in the long run by intensified use of the remaining stock. Employing a model of demand, supply and stock equations for timber Mäki-Hakola (2004) examines the effects of increasing the share of the conserved forests in Southern Finland from the current level of 2.2% to 5.0% or 10% of the forest land in 2005–2008. He finds that conservation would have relatively small price and quantity effects. The possibility to substitute decreasing domestic

roundwood supply with imported wood is concluded to have an important effect on domestic harvests (Mäki-Hakola and Toropainen 2005).

From foreign studies linking forest conservation and markets can be mentioned e.g., Perez-Garzia and Lippke (1993), who conclude that a 10% set-aside of forest inventories for conservation would result in permanently reduced harvest levels in tropical forest countries. Sedjo et al. (1994, see also Uusivuori and Kuuluvainen 2001) point out that local reduction in timber supply caused by forest conservation will be offset by trade-transfers. According to Sohngen et al. (1999), forest conservation may cause leakage harvesting in other currently inaccessible forests. Bolkesjø et al. (2005) analyse economic impacts of forest conservation in Norway and Kallio et al. (2006) in the whole Europe. Their results suggest that while forest conservation leads to a decrease in fellings, the change in aggregate stumpage income of the forest owners is small because of the increase in wood prices. The rise in roundwood prices means increased raw material costs for the forest industry, which causes production cuts in the wood-working sector.

Although there are previous results on economic effects of forest conservation in Finland, analytical in-depth studies on timber market price and quantity effects as well as effects on forest industry production in the longer run are lacking (Ministry of the Environment 2002, Pulli and Mäki-Hakola 2004). The present analysis aims to increase information on this important issue. We apply a partial equilibrium model of the forest sector, which offers a system-wide and yet rich-in-detail approach. The method differs from the Finnish studies enabling us to analyse separately the effects of conservation from the other changes in the operation environment of the forest sector. In addition to analyse national market by forestry centres, we analyse roundwood markets by owners and roundwood categories and the forest industry products by several product categories with differing production technologies. The scenarios reach up to 2020. Since the wood imports from Russia is crucial to the Finnish forest sector, we take account of possible import changes in the sensitive analyses.

We consider conserving additionally up to 5% of the commercially usable forest land in

the forestry centres of Southern Finland (Finland excluding the three most northern forestry centres 11–13, see Finnish Statistical Yearbook 2006 for the map, p. 29). Conservation set-asides are targeted to privately owned mature forests that we assumed to have the highest biodiversity values. The reduction in standing stock available for wood production due to conservation is not assumed to reflect fully in the roundwood supply, because the elasticity of wood supply with respect to growing stock of 0.5 is applied. Inelastic response to inventory changes reflects the fact that all the unprotected growing stock or its growth cannot be in reality fully commercially harvestable. Several issues related to e.g., markets affect timber trade and the forest owners' willingness to sell roundwood. In addition, there do exist forest owners, who would leave at least a part of their forests unharvested in any case.

## 2 Method

### 2.1 SF-GTM-model

The analysis uses an updated version of a spatial partial equilibrium model for the Finnish forest sector, SF-GTM (Ronnala 1995). The model integrates growing forest resources, timber supply, the forest industry and the demand for forest products by simulating the behaviour of welfare-maximizing consumers, and profit-maximizing forestry, forest industry and trade. Competitive market equilibria are found by maximizing the sum of producer and consumer surpluses net of transportation costs, subject to the market clearance and constraints limiting the production, consumption or trade (Samuelson 1952). Thereby prices and quantities are determined endogenously.

These type of models are commonly applied in international forest sector analyses focusing on policy, market, and technological issues. Such models include e.g., the Global Trade Model/GTM (Kallio et al. 1987) and the Global Forest Product Model, GFPM (Zhu et al. 1998, Buongiorno et al. 2003). The model used in this study is application of the GTM model. Other such applications include e.g., the CGTM used at Cintrafor

(Cardellicchio et al. 1989) and the EFI-GTM at the European Forest Institute (Kallio et al. 2004).

The SF-GTM-model is static as it calculates the market equilibrium for each year separately. Nevertheless, it includes dynamic features. The solution of any particular year is used for updating the data for the next year. Thereby, changes in the growing stock of roundwood shift the timber supply function (Equation 5) from one period (year) to another. The model updates the growing stock after each period accounting for the harvests and the forest growth. Investments for new capacity are also endogenous. Production capacity additions take place when the specified investment costs and variable production costs are covered by the price in market equilibrium. In the period after investment, the new capacity is treated like the existing capacity, i.e., the investment costs are specified to be sunk. Finally, any data may be specified periodically to reflect trends in factor prices and technological change.

### 2.2 Model Specification

A presentation of how spatial, multi-agent, competitive economic partial equilibrium can be found by employing mathematical programming is given e.g., in Salo and Kallio (1987), or in Ronnala (1995) based on them, while the reader could also refer to Kallio et al. (2004). Because these earlier presentations encompass the SF-GTM model specification for competitive markets used in this study, we keep the model presentation brief.

The model was specified to include 15 regions: 14 Forestry Centres in Finland, and one foreign region for exports of final products and imports of roundwood. The endogenous sector commodities include 6 timber categories (pine, spruce and birch sawlogs and pulpwood), 3 types of sawmill chips, 9 types of pulp, 13 paper and paperboard grades, and 7 mechanical forest industry products.

Let there be various separable activities  $l(l=1,2,\dots,m^i)$  for producing endogenous sector commodities  $k(k=1,2,\dots,n)$  in regions  $i$ . These activities relate to production lines for mechanical forest industry products, pulp and paper and to the supply (harvests) of roundwood. Some activities simply provide conversion possibility

between substitute products, e.g., pine sawlogs to pine pulpwood.

Production possibility set is limited by the capacities for activities  $l$ , e.g., capacities of the existing or potential (investments) production plants of the forest industry. In this study, the activity levels are fixed for the roundwood harvests in state and company forests and for the harvests in a foreign region that is assumed to be imported to Finland.

Let  $y_i = (y_l^i)$  be the vector of the activity levels in region  $i$ , and let  $\bar{K}_l^i$  be the upper bound (e.g., mill capacity) and  $\underline{K}_l^i$  the possible lower bound for activity  $l$ . Let  $A^i = (a_{kl})$  be a  $n \times m^i$  matrix of input-output coefficients of endogenous sector products  $k$  in activities  $l$  in region  $i$ . If  $k$  is main product of the activity  $l$ ,  $(a_{kl}) = 1$ , if  $k$  is by-product,  $(a_{kl}) \geq 0$ , and if  $k$  is input,  $(a_{kl}) \leq 0$ .

Let  $C_l^i(y_l)$  be the function of marginal costs in activity  $l$  that excludes the costs of endogenous sector (wood, pulp) inputs. For timber fellings of the private forest owners, this function is of the form  $c_k^i + \alpha_k^i y_l^i \beta_k^i$ , where  $k$  refers to wood category obtained from this activity ( $a_{kl} = 1$ ),  $c_k^i$  is the non-stumpage part of the timber supply function,  $\alpha_k^i$  is a scale parameter, and  $\beta_k^i$  is the inverse price elasticity for roundwood supply (The timber supply dynamics is elaborated below). For forest industry production activities,  $C_l^i = -\sum_f \pi_f^i a_{fl}$ , where  $\pi_f^i$  is the unit price and  $a_{fl}$  is the input-coefficient of exogenous sector production factor  $f$ . In the data, we disaggregate exogenous inputs  $f$  to electricity, heat, labour, waste paper, capital, and other variable costs.

Finally, let  $q^i = (q_k^i)$  be the vector of consumed quantities, and  $P_k^i$  real price for product  $k$  in region  $i$ . In our application, foreign and domestic consumption was left unseparated, because the Finnish forest industry is highly export-oriented with only small part of the production consumed at the domestic markets. The consumption was assumed to take place in the foreign region only, and thereby in the domestic regions,  $P_k^i$  was set to zero for all  $k$ . Note that the consumption of the endogenous sectors, e.g., pulp consumed in paper making, is taken into account inherently by the matrix  $A^i$ .

$D_{ijk}$  are the transportation costs per unit of product  $k$  from region  $i$  to  $j$ . Let  $e_{ij} = (e_{ijk})$  denote the vector of exports from region  $i$  to  $j$ .

Assume that producers represented by activities  $l$  maximize their profits. The market equilibrium can then be derived by maximizing the following NLP (nonlinear programming) problem, where the objective function (1) is derived by maximizing the sum of consumers' and producers' surpluses net of transportation costs and where the constraints (2) require that all the markets clear (Samuelson 1952). Endogenous products prices are obtained as shadow prices of constraints (2) in the optimal solution.

$$\text{Max}_{q^i, y^i, e_{ij}} \sum_{ik} P_k^i q_k^i - \sum_{il} \int_0^{y_l^i} C_l^i(y_l) dy_l^i - \sum_{ijk} D_{ijk} e_{ijk} \quad (1)$$

s.t.

$$q^i - A^i y^i + \sum_j (e_{ij} - e_{ji}) = 0 \quad \forall i \quad (2)$$

$$\underline{K}_l^i \leq y_l^i \leq \bar{K}_l^i \quad \forall l, i \quad (3)$$

$$e_{ijk} \cdot q_k^i, y_l^j \geq 0 \quad \forall i, j, k, l \quad (4)$$

The equations (1)–(4) define a convex optimization problem. Therefore, any solution satisfying the Karush-Kuhn-Tucker conditions of the problem is optimal. It can be verified that these optimality conditions are in fact equivalent to the conditions of competitive regional equilibrium, where shadow prices given by the material balance constraints (2) equal the respective market prices.

Solving the model above gives the solution for one single period  $t$ . Before solving the model for the next period  $t + 1$ , all the data are updated when relevant. For instance, prices of exogenous sector inputs may be assumed to change in time.

Also the growing stock of roundwood,  $G_{kt}^i$ , is updated from one period to another. Changes in the productive growing stock caused by forest growth, wood harvests or forest conservation set-asides affect the wood supply tightness in a region via the shift parameter  $\alpha_k^i$ . The growing stock levels in the base year 2005 are given as data. Thereafter, the regional growing stock volumes are updated in each period  $t$  employing the specification

$$G_{kt}^i = (1 + g_k^i) G_{k,t-1}^i - \sum_h a_{kh} y_{h,t-1}^i - s_{kt-1}^i \quad (5)$$

where  $g_k^i$  is a growth rate of the growing stock given as data,  $\sum_h a_{kh} y_{h,t-1}^i$  is the aggregated harvests obtained from the model solution in harvesting activities  $h$ , and  $s_{kt}^i$  is the exogenously specified amount set aside for conservation for wood category  $k$ . Assuming elasticity  $\varepsilon_k^i$  for timber supply, the supply shifter  $\alpha_k^i$  is updated in each period  $t$  setting

$$\alpha_{k,t}^i = \frac{\alpha_{k,t-1}^i}{(1 - \varepsilon_k^i + \varepsilon_k^i G_{kt}^i / G_{k,t-1}^i)^{\beta_k^i}} \quad (6)$$

## 3 Data

### 3.1 Forest Industry

The model requires a large amount of data on the entire Finnish forest sector. The main data sources relevant for this study are presented (see also Ronnila, 1995) in the following and in Appendix 1.

In this study, we only consider the forest industry production in Finland. Therefore, we applied the assumption that the real prices of the final outputs are given. We considered it unlikely that the minor, say 10–20% decrease or increase in the production of one single country would significantly alter the world market prices in the long run. This assumption found support when it was tested by varying the Finnish production levels in the global forest sector model EFI-GTM. In the scenario period 2006–2020, we assumed that the real prices of exported products remain at their level of the base year 2005. The base year data on Finnish production quantities and unit prices are presented for main product groups in Table 1. The real input prices from exogenous sector, like wages, fuel energy and imported eucalyptus pulp were assumed to stay at their 2005 level in 2006–2020. For electricity, see Appendix 1.

The Finnish forest industry production units (mechanical forest industry mills or production lines, paper machines and pulp lines) are modelled as individual production activities with the exception of small sawmills that were aggregated regionally. Data for the mills is originally based on Ronnila 1995, but updated. The most important sources for updating are presented in Appendix 1. For the mills with missing data, data

**Table 1.** Characteristics of Finnish forest industry by main product groups in 2005.

Forest industry products	Number of production units	Capacity, mill. t/m <sup>3</sup>	Production <sup>a)</sup> mill.t/m <sup>3</sup>	Unit price <sup>b)</sup> €/t/€/m <sup>3</sup>
Sulphate pulp <sup>c)</sup>	19	8.1	6.8	407
Paper	28	12.2	9.8	591
Paperboard	14	3.0	2.5	677
Sawnwood	170 <sup>d)</sup>	13.3	12.2	170
Plywood	15	1.6	1.3	513
Particleboard	3	0.5	0.45	176
Fibreboard	2	0.1	0.1	309

Sources: Finnish Forest Industries Federation 2006, Finnish Board of Customs. Capacities are based on the SF-GTM model mill data collected from multiple sources.

<sup>a)</sup> Forest industry production was exceptionally low in Finland in 2005 due to a conflict in labour market.

<sup>b)</sup> Export unit values from Finland.

<sup>c)</sup> In addition, mechanical and semichemical pulp are produced at 24 mills, mostly integrated to paper and paperboard production.

<sup>d)</sup> Industrial sawmills.

from the representative mills are used instead. The already known capacity investments plans were modelled as investment possibilities and the known capacity closures were accounted for. For sawnwood, we assumed that the existing capacity is reducing at the rate of 1% per year, but potential new sawnwood capacity (investment options) was defined for all regions and periods. We also defined options to invest in new pulp mills.

### 3.2 Roundwood Market

The demand for domestic wood derives from the production of the forest industry. The supply of roundwood is disaggregated to supply from private, state and company forests. The supply functions of the private forest owners need data on harvesting quantities, and timber prices in the Forestry Centres in the base year 2005 (see Appendix 1). The exogenous part of the supply function includes data on transport (€/m<sup>3</sup>/distance) and harvesting costs. The annual growth rates,  $g_k^i$ , for different wood categories were assessed basing on the 9th National Forest Inventory data on the volumes and number of trees in each diameter class (NFI9, e.g., Tomppo et al. 1998). Their estimates vary across wood species, roundwood categories and the region (Table 3). The NFI9 data was also employed to

**Table 2.** Commercial roundwood removals and stumpage prices by forestry centres in 2005.

Forestry centre <sup>a)</sup>	Commercial roundwood removals, 1000 m <sup>3</sup>						Stumpage prices, €/m <sup>3</sup>					
	Sawlogs			Pulpwood			Sawlogs			Pulpwood		
	S <sup>b)</sup>	P	NC	S	P	NC	S	P	NC	S	P	NC
1a	301	185	36	311	222	121	46	44	38	21	12	11
1b	306	197	6	342	295	246	43	42	32	20	13	12
2	1103	776	52	747	665	304	47	45	35	22	13	12
3	1954	498	153	976	467	404	48	45	41	22	11	11
4	1049	820	97	684	733	354	47	46	43	21	13	12
5	1434	567	71	778	486	283	47	45	40	22	12	11
6	1494	1200	271	905	972	602	47	46	44	21	13	13
7	760	877	26	570	1085	518	44	43	36	20	13	12
8	1646	810	147	960	985	522	47	45	42	21	12	12
9	1781	530	129	1088	731	616	47	44	41	21	12	12
10	921	944	127	764	1150	455	46	45	43	20	13	12
11	329	909	4	478	934	337	42	42	40	21	13	12
12	520	824	14	498	1690	846	40	41	35	18	13	13
13	255	1052	1	523	2060	422	33	39	-	16	13	12

Source: Metinfo, Finnish Forest Research Institute

<sup>a)</sup> Forestry centres 1a–13 respectively: Etelärannikko, Pohjanmaa, Lounais-Suomi, Häme-Uusimaa, Kaakkois-Suomi, Pirkanmaa, Etelä-Savo, Etelä-Pohjanmaa, Keski-Suomi, Pohjois-Savo, Pohjois-Karjala, Kainuu, Pohjois-Pohjanmaa, Lappi.

<sup>b)</sup> S=spruce, P=pine, NC=birch

**Table 3.** Growing stock of private forests in 2005 and growth rates applied in the analysis.

Forestry centre	Growing stock in private forests, mill. m <sup>3</sup>						Volume growth rates, %/year					
	Sawlogs			Pulpwood			Sawlogs			Pulpwood		
	P	S	NC	P	S	NC	P	S	NC	P	S	NC
1a							2.8	5.2	3.9	3	2.3	3.2
1b <sup>a)</sup>	10.5	12.5	3.7	29.6	24.8	17.7	3.9	5	5.6	4.4	3.3	5
2	23.3	21.3	3.2	36.5	28.6	19.6	3.5	4.7	4.5	3.2	2.3	4.4
3	15.6	31.8	5.6	16.9	33.3	23.6	3.2	4.5	3.8	3.5	2.6	4.1
4	15.6	15.2	3.4	23.7	22.3	15.2	3.5	4.6	4.1	3.6	2.8	3.8
5	13.7	20.0	3.0	21.3	27.1	19.0	3.8	4.7	4.4	4	3.3	4.7
6	26.1	20.9	4.9	29.9	25.0	24.2	3.1	4.5	3.7	3.9	3.2	4.1
7	16.4	8.4	1.5	47.1	15.6	21.7	4.4	5	6.2	3.7	3.3	5.2
8	16.2	19.4	3.0	30.7	28.8	22.7	3.8	4.9	4.8	3.7	3.2	4.5
9	14.5	24.5	3.2	22.2	26.3	28.7	3.5	4.7	4.5	3.7	3.2	4.7
10	15.3	14.2	2.0	29.2	17.9	19.7	3.8	5.1	4.6	3.7	3.6	4.6
11	9.2	3.8	0.3	26.4	7.3	10.8	4.4	3.8	5	4	3.5	4.7
12	16.7	6.8	0.7	61.4	18.3	29.2	5	4.2	5.5	4.1	3.3	4.6
13	12.3	3.7	0.2	52.7	16.7	18.0	3.9	4	5.9	4.2	3.7	4.7

Sources: Volume growth rates are calculated using the NF19 inventory results of the Finnish Forest Research Institute (e.g. Tomppo et al. 1998). Updating method of the growing stock for 2005, see Uotila (2005). Symbols, see Table 2.

<sup>a)</sup> Growing stock figures on line 1b are a sum of regions 1a and 1b.

calculate the land-growing stock (hectares) correspondence needed to define conservation set-asides,  $s_{kt}^i$ , in cubic meters for roundwood categories  $k$  (see also Fig. 5). The growing stocks,  $G_{kt}^i$ , in 2005 are based on Uotila (2005).

Price-elasticities of supply from private forests,  $\beta_k^i$ , were assumed to be 1.0 for all roundwood categories. In earlier studies, statistically significant estimates vary a lot. In Hänninen et al. (2006), the regional long-term price elasticities for different wood categories were in many cases close to one. The price elasticities have been difficult to assess because of the significant structural changes in the Finnish roundwood markets in 1980's and 1990's, e.g., the gradual dismantlement of the nationwide price negotiation system.

The elasticity of supply with respect to forest stock,  $\varepsilon_k^i$ , was assumed to be 0.5 for all roundwood categories, while we also provide sensitivity analysis for the elasticity 1.0. The elasticity estimates are scarce in the literature, and unit elasticity is often used because of lack of better estimate (e.g., Cardellicchio and Adams 1990). Econometric studies indicate problems in estimating this elasticity for Finland too, but theoretically feasible estimates (between 0.3 and 1.0) have been obtained from forest owner specific data (Ovaskainen and Kuuluvainen 1994, p. 49).

State and company fellings are defined exogenously for 2006–2020 due to lack of meaningful price elasticities of supply for state (Piiparinen 2001) or company fellings. The data suggest that the company and state harvest are not necessarily correlating with timber price, but that the market prices are determined by the timber sales between the private forest owners and the industry. From the total Finnish commercial removals (53 mill. m<sup>3</sup> in 2005), 84% originates from private forest owners, 7% from companies, and 9% from the state (Finnish Statistical Yearbook of Forestry 2006, p. 186–187).

### 3.3 Wood Imports

Data on roundwood imports include import quantities of the six wood categories, chips and eucalyptus pulp. The demand for imported wood is modelled as a derived demand, while the aggregated supply of wood imports (1000 m<sup>3</sup>) to Fin-

land was defined exogenously. Thus, imported roundwood supply was assumed inelastic with respect to price. Previous research in the Finnish elasticities of import are scarce. According to Tilli et al. (2002) imported pine pulpwood has been a substitute for Finnish pine and in the main import source, Russia, pricing strategy has concluded to follow Finnish pulpwood stumpage prices. Global results for import demand indicate inelastic timber imports (e.g. Uusivuori and Kuuluvainen 2001, -0.92, Turner and Buongiorno 2004, -0.74).

A common opinion in Finland regarding the roundwood imports is that it is more likely that they decline in the future than continue to grow (e.g., Hetemäki et al. 2006, p. 83–85). About 80% of the imports originate from Russia, where the authorities have presented plans to decrease roundwood exports. For this end, the tariffs on roundwood exports have already been increased and further increase are expected. Increasing investments in woodworking industry in Russia is also raising the sawlog demand there, which is likely to limit the future sawlog supply for exports.

The issue of roundwood imports from Russia is addressed in the present study by two separate sensitivity analyses: one for the base scenario and another for the conservation scenarios.

## 4 Scenarios of Forest Conservation

Scenarios where 0.5% to 5% from the forest land in Southern Finland is set-aside to conservation in 2008 is compared to the base case (BASE) with no additional conservation. Two alternatives are considered regarding reaction of the wood imports to the conservation. First, it is assumed that wood imports do not react to the increased conservation in Finland (no leakage of harvests). Secondly, it is assumed that a certain share (30%) of the decline in domestic harvests caused by increased conservation is substituted by rising wood imports.

Two sensitivity analyses are provided. The first one addresses the situation where future wood exports from Russia to Finland show a declining trend in the base case. The second case deals with

changing the assumption of the elasticity of the wood supply with respect to the growing stock from 0.5 to 1.0.

### 4.1 The Base Line Projections

In the base line case, BASE, the imports were assumed to stay at their 2005 level of 21 mill.m<sup>3</sup> during the whole period studied (2005–2020). Projections of BASE with no additional forest conservation are presented in Fig. 1 and 2. Due to an exceptionally long strike in the pulp and paper industry, which affected the entire Finnish forest sector in 2005, the base case development is discussed below making comparisons to the year 2004.

In the base case, clear differences exist in the end-use sectors of pulpwood and sawlogs in 2020. Sawnwood production is about 14% lower in 2020 than in the year 2004. The percentage decrease in coniferous sawlog harvest related to the sawnwood production decrease is roughly of the same magnitude, 16%. The decrease in demand presses the stumpage price of coniferous sawlogs down only about 5%, mainly because of the scarce supply of spruce sawlogs. There are in fact clear differences between the wood species. The price of pine sawlog falls 12%, while the

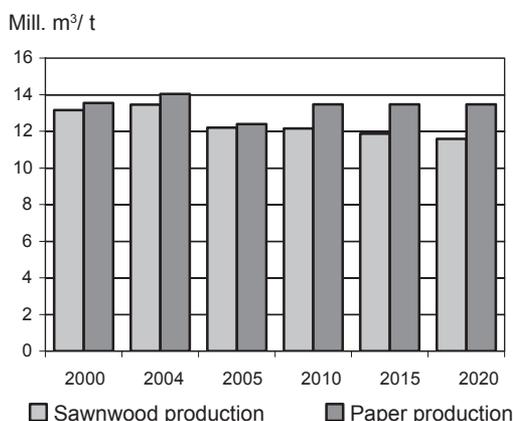


Fig. 1. Production of final products in Finland in the base case.

stumpage price of spruce sawlogs remains at its 2004 level in 2020. The supply tightness results from the market changes during 1990's. Harvests of coniferous sawlogs, especially spruce, have been expanding along with the unusually high increase in sawnwood production capacity during the 1990's. At the same time, supply and harvests have increased due to the 13-year transition period (1993–2005) of the forest taxation reform (e.g., Mutanen and Toppinen 2005).

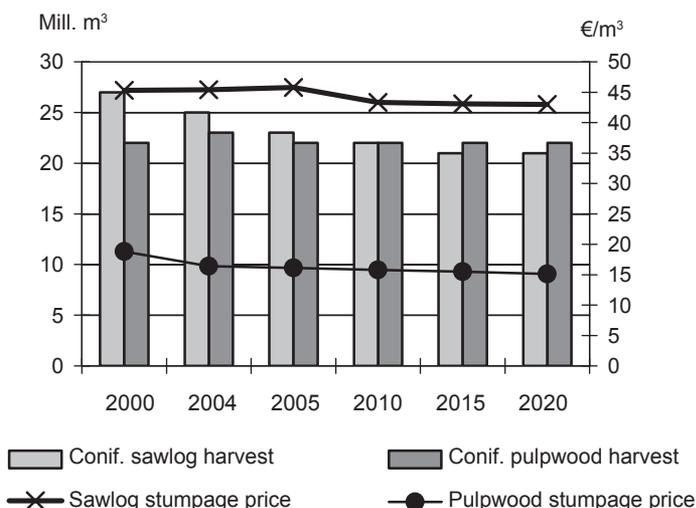


Fig. 2. Roundwood harvests and stumpage prices in Finland in the base case.

Paper and paperboard production is projected to change less than sawnwood production. During the first years of the scenario period, production falls due to the closures of unprofitable production units. Compared to the year 2004, the fall in paper production is about 4% in 2020. Coniferous pulpwood harvests decrease only by about 1% in the same period. The decrease remains small, because the reduction in supply of wood chips from domestic sawmills is compensated by domestic harvests. Nevertheless, the increase in the growing stock of pulpwood boosts the effect of decreasing demand on pulpwood prices that are projected to decrease by 8% from 2004 to 2020.

### 4.2 Impacts of Increased Forest Conservation If Conservation Does Not Affect Wood Imports

The effects of increased conservation are examined by creating comparative projections for BASE where 0.5%, 1.0%, 1.5%, ..., 5% of the forestry land area in South Finland is set aside for conservation in the end of 2008. Wood imports were assumed to stay in their BASE level despite of forest conservation increasing domestic wood prices and reducing demand.

Conservation set-asides were taken in the same proportions from the forest land in the forestry centres of South Finland. The conservation sites were assumed to be picked evenly from the distribution of the forest owners with different preferences for the use of their forests. The set-asides were targeted to the privately owned mature (old-growth) forests that have a higher density (m<sup>3</sup>/ha) than the average forestry land in Finland. Fig. 5 exhibits, for comparison, how hectares correspond to the volume of growing stock in this case. For example, 5% of the forestry land area conserved in South Finland corresponds to about 8% from growing stock in the whole country. Naturally, if conservation sites had been taken also from younger forests, the effect on the growing stock would have been smaller. All conservation projections, set-asides from 0.5% to 5%, were analysed separately vis a vis to BASE.

Fig. 3 presents the percentage changes brought in by the conservation set-asides in BASE in 2015.

Conservation causes a negative shift in the roundwood supply, which increases roundwood prices. The increased wood costs affect the wood demand in the forest industry. In the sawmill industry, roundwood price is a considerably more important cost component than in the paper indus-

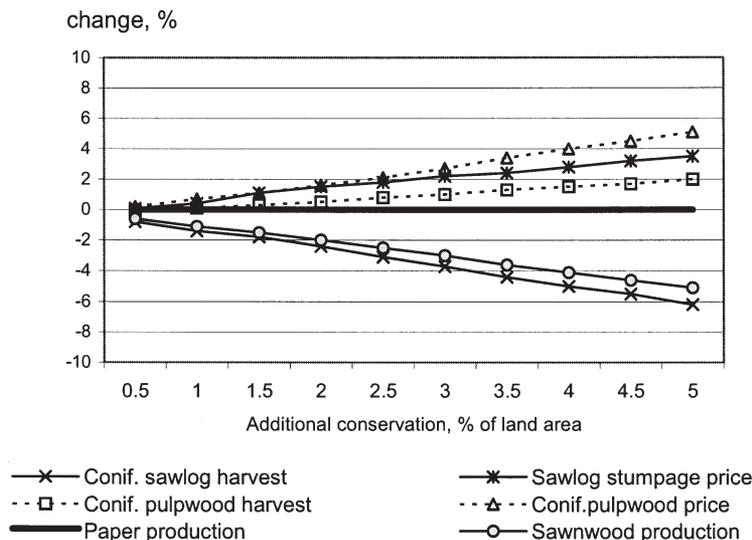


Fig. 3. Impact of conservation set-asides on selected variables with respect to the base case.

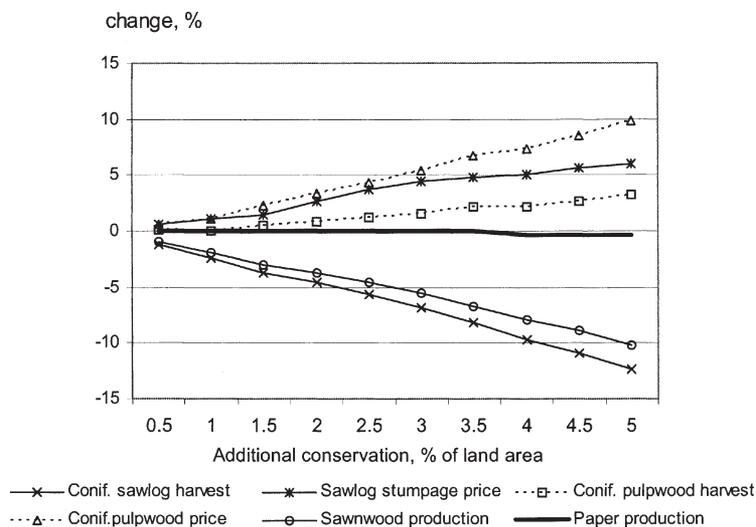


Fig. 4. Impact of conservation set-asides on selected variables when  $\varepsilon_k^i = 1$ .

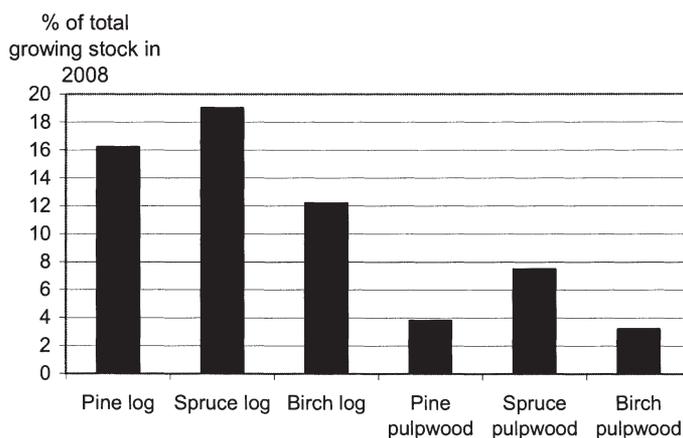


Fig. 5. Volume of roundwood stock related to the 5% additional forest conservation in Southern Finland, % of total growing stock in state and private (excluding companies) forests in Finland.

try. With conservation set-asides ranging between 0.5–5% from the mature forest hectares in South Finland, reductions in sawmill production levels range between 0.6–5.1% compared to the BASE line in 2015. Demand and harvests of softwood

logs reduce 0.8%–6.2%, while sawlog prices increase 0.1%–3.5% depending on the set-aside percentage in 2015.

Targeting conservation to the mature forests means that the share of sawlogs removed from

the timber market is higher than the respective share of pulpwood (Fig. 5). However, the pulpwood prices are projected to increase more than the sawlog prices, from 0.2% to 5.1%, depending on the set-aside percentage. This is because the demand for pulpwood does not adjust downwards as does the demand for sawlogs. Instead, pulp and paper production remain at their base case levels, and the demand for pulpwood increased due to the need to substitute the reduced supply of sawlog chips by roundwood. The coniferous pulpwood harvests increase by 2% under 5% increment in conservation.

The percentage increments in stumpage prices and harvests of coniferous pulpwood offset the decrease in the log harvests. Thus, the forest owners are unaffected or better off after conservation. This is, of course provided that adequate compensation is given for the conserved land, but that is secured by law. If conservation is based on the new voluntary methods of the METSO-program, conservation increases the forest owners' alternatives for earning income from their forests by enhancing their marketable production possibility set.

### 4.3 Impacts of Increased Forest Conservation If Conservation Increases Wood Imports

Wood imports are assumed to increase due to rise in domestic prices caused by forest conservation (e.g. Sedjo et al. 1994, Kallio et al. 2006). In the following, we assumed that the increase in wood imports from Russia offsets 30% of the change in domestic harvests caused by conservation (in post-conservation periods 2009–2020 as calculated from the scenarios without import substitution described above). This was considered feasible in the light that the Finnish wood imports were higher than ever in 2005–2006, whereas Russia is planning to reduce its roundwood exports in order to attract forest industry investments. Furthermore, the magnitude of import substitution applied is in line with findings in the study of Kallio et al. (2006). We limit our discussion to the cases with 1.5%, 3% and 5% conservation set-asides.

The results are shown in Fig. 6. If wood imports increased to offset 30% from the domestic pine and spruce sawlog harvest reduction or decreased to offset the respective harvest increase of pine

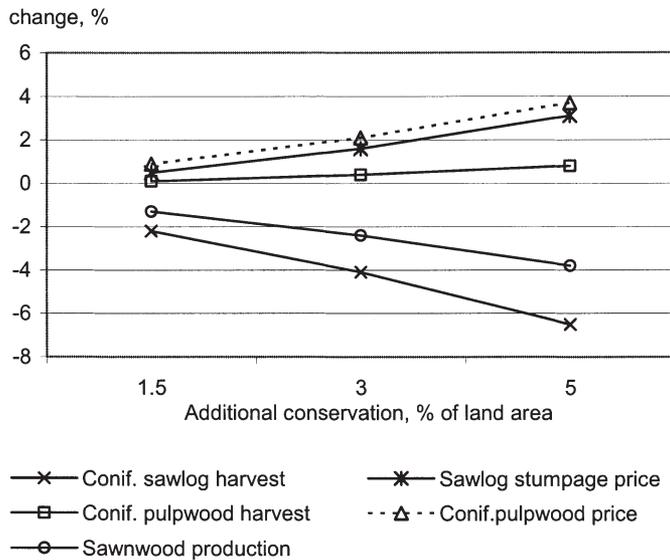


Fig. 6. The effects of forest conservation with respect to the base case when roundwood imports substitute for 30% of the domestic harvests changes due to conservation.

pulpwood, the impacts of forest conservation in the Finnish forest sector would change as follows. Now the stumpage prices increase a bit less than in the case of no import substitution indicating smaller cost rises of domestic wood for forest industry. Price increases range for domestic sawlogs from 0.5% to 3.1% and for pulpwood 0.9% to 3.7% with 1.5–5% conservation set-asides. Reductions in sawnwood production are also smaller ranging from 1.3% to 3.8%. Sawlog harvests reduce more, from 2.2% to 6.5%, because of their higher import quantities. Pulp and paper production remains at their base levels, but the rise of domestic pulpwood demand and harvests is smaller, from 0.1% to 0.8%, than in the case of no import substitution.

The possibility to substitute domestic wood with imported wood makes forest owners' aggregated income to decrease. This is because sawlog harvests decrease clearly more than the sawlog prices increase. Pulpwood prices increase slightly more than the sawlog prices, and their harvests increase less than 1% in all the cases. At the level of 1.5% additional conservation, which appears to be quite plausible alternative in the current forest policy discussion, the forest owners' aggregate income reduction is about 1%. Nevertheless, considering the annual price variations taking place in the Finnish roundwood market (e.g., Toppinen and Uotila 2005), this can be considered a small change.

#### 4.4 Sensitivity Analyses

##### 4.4.1 Sensitivity Analysis for Import Reduction Compared to the Baseline Case BASE

Below, it is assumed that Finnish wood imports decline to the level of 15 mill. m<sup>3</sup> in 2008 where they remain for 2009–2020. This total decline is assumed to encompass a 35% fall in the pulpwood and sawlogs imports, but a 20% rise in wood chips imports from 2005 to 2008. So, the supply of chips from Russian sawmills to Finland is assumed to continue its growth.

In the sawnwood industry and sawlog markets, the new base case developments (assuming no additional conservation) indicate a larger decrease

in production and harvests than the original base case (BASE) with larger wood imports. Differences are, however relatively small. The pulpwood market is a bit more sensitive to the assumed import decline. The decrease in pulpwood imports and the projected decline in domestic supply of sawmill chips cause now an 8% increase in the coniferous pulpwood demand and harvests. Due to the demand rise, domestic pulpwood price rise 5% from the 2004 level by 2020, despite of the assumption of rising imports of wood chips.

Varying the conservation percentage from 0.5% to 5% and assuming that the imports do not react to conservation now leads the sawmill production to fall from 0.4% to 4.2% and sawlog harvest to fall from 0.2% to 4.2% compared to the new base case. The sawlog price increases range from 0.7% to 3.9%. In the pulpwood market, the respective changes vary between 0.3%–4.4% for prices and 0.1%–1.6% for harvests. For forest owners these figures mean a slight increase, about 1%, in stumpage income. Pulp and paper production is again unchanged. Hence, it seems that the relative impacts of forest conservation are rather insensitive to the assumption on the base case wood imports, staying at 21 mill. m<sup>3</sup> or declining to 15 mill. m<sup>3</sup>.

##### 4.4.2 Sensitivity Analyses with Growing Stock Elasticity 1.0

Because the inventory elasticity of wood supply has a direct impact on the market supply of timber after the conservation set-aside, a sensitivity analysis was calculated to the case with stock elasticity,  $\epsilon_k^i$ , increased to 1.0 for all regions and wood categories. This corresponds to the assumption that if a certain percentage of growing stock is set-aside, the wood supply reduces by the same percentage given no changes in the market prices. The results are presented in Fig. 4. The higher the stock elasticity of the roundwood supply is, the larger the impacts of forest conservation on price, harvests and sawnwood production are. However, paper production remains unchanged also in this scenario. Roughly, we may say that all the other impacts are doubled from the 0.5 elasticity case.

## 5 Discussion

The advantages of the SF-GTM-model applied in the study are in the regionality, detailed description of the forest industry and the description of the roundwood market by wood category. When assessing the results of the present study, it is stressed that conservation set-asides was targeted to old-growth forests where the density is higher than in the average forestry land. Thus, the results can be interpreted as maximum effects of increased forest conservation. In reality, the conservation impacts probably remain smaller than indicated here; not all the forests that are rich in valuable biotopes are necessarily mature, high-density forests.

We may compare our results to econometric studies. In Linden and Uusivuori (2002), a 10% decrease in the commercially usable private timber stock contracts total timber sales volumes by 4% and causes a similar increase in timber prices. Roundwood import effect was not modelled. The relatively low timber sales effect was explained by intensified harvesting in the remaining forests. Leppänen et al. (2000) suggest that increased conservation would have large impacts on roundwood markets. A set-aside of 10% of the forest land in South Finland decreased the pulp and sawnwood production about 5%. The maximal impacts under 10 years forecasting period on pulpwood harvest was about 17% decrease in volume and a 15% rise in price. For sawlogs the quantity and price effects were -18% and 14%, respectively. Longer-term effects were clearly smaller especially in the case of sawlogs. Mäki-Hakola (2004) suggests that increasing the share of the protected forest area in South Finland to 10% level in 2004 would cause only a 3% decrease in fellings and a similar increase in wood price during 2005–2008.

Our study complies with the ones above suggesting that the forest industry is loosing from the conservation and that the forest owners are not necessarily hurt by conservation. Financial compensation from the state for the lost harvest income shrinks the burden of forest owners, but the forest industry faces increasing costs in the form of rising stumpage prices.

In our study, sawmills faced the strongest effects in the form of a cost rise. The negative shift in roundwood supply induced by 5% additional

conservation led to a 3.5% rise in sawlog prices and a 5% fall in production compared to the base line. The rise in pulpwood prices (5%) was higher than that in sawlog prices. Still, in the paper industry, the share of wood in production costs is relatively small. This is why the production quantities of paper and board were unaffected. However, a rise in costs weakens the profitability that may lead to production decreases at longer term. Forest owners are unaffected at aggregate level, because increased stumpage prices offset the decrease in harvests.

The conservation impacts were not very sensitive to our assumption on the base case wood imports staying at 21 mill. m<sup>3</sup> or declining to 15 mill. m<sup>3</sup>. Instead, the possibility to substitute domestic wood with imported wood had more impacts. We analysed the case where 30% of the domestic harvest change, caused by additional forest conservation, is substituted by the imported wood. Now, the increases in stumpage prices were smaller, 3% for sawlogs and 3.7% for pulpwood, indicating that forest industry is better off in form of cost rise than in the case of no import substitution. Because domestic harvests of coniferous roundwood decreased more than the stumpage price increased, the forest owners' income is a bit smaller in the case of import substitution. A conservation set-aside of 1.5% decreased the forest owners' aggregate wood-sales income by 1%.

When interpreting the results certain limitations must be noted. There are factors not included in the present study that may affect the impacts of the conservation on the forest sector and the direct costs of conservation. Among these is the assumption on the exogeneity of roundwood imports. Large increases of imports from Russia because of additional forest conservation are not probable. If the current Russian policy plans to rise the roundwood export tariffs gradually in the next few years are realized, wood imports to Finland may decrease considerably. This might have large effects overall Finnish forest sector. Therefore, further research in the issue of wood imports is called for. The forest industry firms have already started to adapt to the possibility of declining imports by increasing their demand for domestic wood, which has been one of the reasons for the exceptional rise of stumpage prices in Finland in 2006–2007. Among the other factors

excluded in this study, are the possible environmental good-will related to forest products and increased demand for wood for bioenergy. Demand increments of forest industry products induced by environmental good-will or increases in pulpwood use for bioenergy would lead to increasing harvests and wood prices.

The impacts of the new METSO voluntariness-based and traditional conservation actions are not separately analysed, because of the lack of information on forest owners' attitudes. Among the new voluntary instruments is, for example, natural values trading. Participating in the natural values trading, a forest owner is economically compensated of maintaining ecological values in his forest for 10–20 years. After this period, commercial use of the forest is possible. In competitive tendering, landowners may offer to rent or sell valuable areas to the authorities. In setting up voluntary nature management areas, forest owners are economically compensated for the resulting income reductions. In either case, it is required that the land accepted for such contracts satisfies the predetermined ecological criteria.

The possible difference in the impacts of the new METSO voluntariness-based and traditional conservation actions depend on how much such land enters the programme that would be left unharvested in any case. Overall, harvestable standing stock is reduced, when commercial forests are set aside for conservation. According to Mäki-Hakola and Toropainen (2004) new instruments tend to have smaller regional effects on production, employment and the value added compared to strict conservation.

It is worth stressing that all future scenarios are conditional to their primary assumptions and the data used. Changes in basic assumptions naturally change the final outcome. Nevertheless, scenarios provide decision makers an insight of alternatives under different assumptions. They also offer a key to understand future uncertainty when decisions must be made upon the conservation policies.

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*Total of 43 references*

**Appendix 1.** Main data sources.

Data	Description and data sources
Regions	Data are for 14 Finnish Forestry Centres.
Reference prices	Export unit prices of forest industry products, €/m <sup>3</sup> or €/t. Source: <i>Finnish Board of Customs</i>
Prices of exogenous sector inputs	<p>Wages including social security fees are annual averages per person for the whole country, in €. Wages are disaggregated by production of sawnwood, plywood, fibreboard, particle board and pulp and paper. Source: <i>Statistics Finland, Regional and Industrial Statistics on Manufacturing</i>. <a href="http://www.stat.fi/">http://www.stat.fi/</a></p> <p>The electricity price for the base year 2005 was 0.069 €/kWh. For 2006 the price applied was 0.070 €/kWh, which is for middle-sized industry with electricity consumption over 10 mill. kWh/a quoted in the beginning of the year 2006. For 2007–2020 the price was assumed to be 0.08 €/kWh. The biggest forest industry companies (e.g., UPM-Kymmene) were assumed to get 25% discount from these prices. Sources for 2005–06: <i>Energy Review 2/2006</i>. <i>Energy Market Authority</i>.</p> <p>Fuels: the price was assumed to be at the level of 2005 (8.1 €/GJ) during 2006–2020. The price is based on the consumer prices of heavy fuel oil. Source for 2005: <i>Energy Review 4/2005</i>. <i>Energy Market Authority</i>.</p> <p>The price of imported eucalyptus pulp was assumed to stay at the 2005 level (400 €/t) during 2006–2020. Source: <i>Finnish Board of Customs</i>.</p>
Production units	<p>Capacities and the input-output coefficients for the raw materials, labour, energy and other costs. Sources: <i>Original data is from Ronnila 1995</i>. Main sources for updates:</p> <ul style="list-style-type: none"> <li>• <i>The EMAS (European Unions's Eco Management and Audit Scheme) reports of the individual plants ( e.g., <a href="http://ec.europa.eu/environment/emas/es_library/library_en.htm">http://ec.europa.eu/environment/emas/es_library/library_en.htm</a>), 1999–2005.</i></li> <li>• <i>Companies' internet pages and annual environmental reports (whenever available, press reports of the new mills and shutdowns)</i></li> <li>• <i>Environmental permit applications/decisions of the mills from the years 1999–2006 (internet pages of the Ministry of Environment, <a href="http://www.ymparisto.fi">www.ymparisto.fi</a>)</i></li> <li>• <i>Paper profiles of the UPM-Kymmene and M-real paper grades (for information on paper profiles see e.g., <a href="http://www.paperprofile.com/">http://www.paperprofile.com/</a> or <a href="http://www.m-real.com/Paper+Profiles">http://www.m-real.com/Paper+Profiles</a>)</i></li> <li>• <i>The Environmental reports for the wood products industry for 1999–2004 produced by the Finnish Forest Industries Federation (collected annually from <a href="http://www.forestindustries.fi/julkaisut/">http://www.forestindustries.fi/julkaisut/</a>)</i></li> <li>• <i>Energy inputs: e.g., Lähpelto (1998).</i></li> </ul>
Roundwood market	<p>Harvesting quantities (1000 m<sup>3</sup>) and unit prices (€/m<sup>3</sup>). Sources: <i>Finnish Statistical Yearbook of Forestry and Metinfo databank</i>. <i>Finnish Forest Research Institute</i>.</p> <p>Forest growing stock (1000 m<sup>3</sup>) for 2005. Sources: <i>NFI9</i>, e.g., <i>Tomppo et al. 1998</i>, <i>Uotila 2005</i>.</p> <p>Transport costs of roundwood in Finland (€/m<sup>3</sup>) is based on Metsäteho company's data and harvesting costs (€/m<sup>3</sup>) on forest inventory reports (e.g. Hirvelä et al. 1998).</p>
Roundwood imports	Roundwood import quantities (1000 m <sup>3</sup> ) and unit prices (€/m <sup>3</sup> ). Source: <i>Finnish Board of Customs</i> .