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Roundwood pricing mechanisms and their performance in Scots pine roundwood markets

Jukka Malinen, Vesa Berg and Harri Kilpeläinen

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Abstract

Roundwood is a heterogeneous raw material, which means that different species, qualities and dimensions have different value potential for different end-uses. As a result, the value of bought roundwood raw material is dependent on the properties of the raw material as well as the selected end-use. These timber assortments are categorised as forest products and the payment is based more or less on timber assortment volumes with the prices negotiated between the seller and the buyer.

The optimal pricing mechanism is related to sale type (standing sales, roadside sales or delivered sales) and measurement of raw material, but in general, the optimal pricing mechanism should include the following aspects: It should not restrict value optimization of raw material, it should be transparent and easy to understand and it should offer incentives to grow higher quality raw material.

In this paper, five pricing mechanisms for clear-cutting stands were tested: timber assortment pricing, weighted timber assortment pricing, stem pricing, fractional stem pricing and price list pricing. Stem pricing and fractional stem pricing offers freedom to cut stems as wanted and, thus, optimise the raw material according to the existing market demand and the use of these pricing mechanisms in clear-cutting standing sales has advantages. In delivery sales, price list pricing has clear advantages. It gives the seller an indication of what kind of timber is valuable, and if the price list is correct the outcome of bucking should meet the needs of the buyer.

Keywords

Roundwood markets, roundwood pricing, pricing mechanisms

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Preface

This paper is an output of the Northern Periphery Programme funded project “Developing the Scots Pine Resource”. The overall aim of this project is to stimulate the development and optimal utilisation of the Scots pine resource as a basis for sustainable, competitive, small- and micro-scale rural industries. One of the tasks in the project was to analyse timber pricing mechanisms and to identify the scenarios and pricing mechanisms which lead to suboptimal use of pine resource.

The authors acknowledge the help and support of all the partnership of the project, but the special acknowledgements goes to Erkki Verkasalo, Finnish Forest Research Institute, Elspeth Macdonald, Forest Research, Lisa Classon, Skogsstyrelsen and Peder Gjerdrum, Skog og Landskap. We are also grateful for Aino Lindsay for revising the English.

Contents

1 Roundwood trading mechanisms

Forestry and forest industries are important for many countries, especially for rural areas, since they provide income and job opportunities. Therefore market efficiency is important, although roundwood markets are often described as inefficient markets due to spatial oligopsony.

In northern Europe, the number of private forest owners is high and the share of roundwood originated from these forests plays a significant role in Europe's forestry. Thus, wood procurement companies are dependent on multiple suppliers. For example, in Finland, the number of individual private forest owners is estimated at 920 000, which means that almost every fifth Finn is a forest owner. This fragmented ownership structure means that a single wood buyer may buy and harvest thousands of individual stands annually, whereas a forest owner may sell roundwood once in a decade. As a consequence, the forest owners' decision-making position is more that of a customer than a supplier. This even more so, as the roundwood market has developed to become more similar to markets for other capital goods: the volumes offered in the market depend more on price expectations and less on capacity and cost to produce those volumes (Gjerdrum 2008).

In the roundwood markets, there are typically many sellers and few buyers. This leads to oligopsonic markets, at least for pulpwood, and the possibility of market inefficiency occurs. According to Brännlund (1989), a considerable social loss is a consequence of monopsony in the Swedish pulpwood market. Størdal and Baardsen (2000) propose that the Norwegian sawlog market has been non-competitive. Simulations of the Finnish pulpwood market from 1988 to 1997 by Kallio (2001) suggest that the market may have been non-competitive during the recession years.

Roundwood is a heterogeneous raw material, which means that different species, qualities and dimensions have different value potential for different end-uses. As a result, the value of bought roundwood raw material is dependent on the properties of the raw material as well as the selected end-use. Hence, purchasing of a marked stand is also the starting point of the procurement chain; it sets the first constraints on fulfilling the mills' demand for raw material. The prices and price system should allocate revenue upstream from industry to forestry in a just and efficient way (Gjerdrum 2008). Prices tell the forester how to do silviculture to obtain the right wood quality (in the long term), which stand to choose for harvest each year (short term), and how to buck and sort each stem into pulp- and sawlogs (instant term).

Although there is a lot of variation between the pricing mechanisms used in different countries due to the structure of buyer and seller parties, and harvesting and timber measurement methods, some similarity can be found. Timber assortments are categorised as forest products and the payment is based more or less on timber assortment volumes with the prices negotiated between the seller and the buyer. However, if the purchasing is done for the standing sale and the cut-to-length method (short-wood method) is used, it is almost impossible to know the best bid beforehand. Length-diameter restrictions vary between different buyers and the actual volumes or proportions of assortments are difficult to predict.

There are several different methods to trade roundwood and they can be categorised into two different classes: standing sales and delivery sales. The main difference between these sale types is who harvests the timber and makes the decision how to buck the trees. This also affects the pricing mechanisms used in the pricing of roundwood.

In standing sales, the forest owner sells the permission to harvest, haul the logs to roadside and transport them to production plants. The advantage is that the buyer is able to optimize the harvesting schedule, transportation logistics and even carry out just-in-time bucking optimisation according to the market demands. The disadvantage is that in the standing sale the forest owner usually does not know the exact price for the sold timber, only unit prices for timber assortments and estimates of volumes and assortments to be cut from the marked stand are known.

Delivery sales can be further divided into two subgroups, roadside sales and delivered sales. In roadside sales, the forest owner, or company authorised by the forest owner, harvests the timber according to given timber assortments and their dimension and quality restrictions, and hauls the logs to roadside. The buyer is responsible for the transportation of logs from the roadside to production plants. In the delivery sales, the forest owner, or company authorised by the forest owner, harvests the timber, hauls the logs to roadside and delivers the assortments to the agreed production plants.

Depending on sale type, sold roundwood can be measured by pre-harvest measurements, measurements during harvesting, during transportation or at the production plant. Pre-harvest measurements are the most expensive and the most inaccurate method to measure roundwood for trade, and therefore, for example, in Finland the pre-harvest measurements have not been done since the early 1990s. Measurements made by harvesters are the cheapest way to measure roundwood for trade. Measurements made at roadside or at production plants are more expensive than harvester measurements, but the advantage is the ability to measure quality more efficiently.

Depending on the measurement method roundwood is priced according to volume or weight. Weight measurements are often used in pulpwood or energy wood trade. It is possible to measure roundwood by weight although the trade is done by volume, but in these cases the transformation from the weight measure to volume measure has to be done by using transformation models or tables.

For a more detailed description of Roundwood markets in Finland, Norway, Scotland and Sweden please see the book “Markets for Scots Pine Roundwood”, (editor Peder Gjerdrum) http://www.pineinfo.eu/userfiles/file/Market Review.pdf

2 Roundwood trade in Finland, Norway, Scotland and Sweden

2.1 Finland

In Finland, 62% of used timber in 2008 originated from privately owned forest, 16% was from state or companies' own forest and the rest was exported (Metinfo 2010). It is estimated that there are almost 450 000 private forest holdings which are owned by 920 000 forest owners. In practice, each forest owner is obligated to belong to a Regional Forest Management Association. The Act on Forest Management Associations enables Forest Management Associations to collect a forest management fee from forest owners. Every forest owner pays the fee and thus is automatically a member of the Forest Management Association in the area where his or her forests are located. Forest management fees account for approximately 20% of the associations' turnover. The rest is generated by the services provided for forest owners.

About 80 – 90% of the activities related to timber production in private forests as well as approximately 75% of preliminary planning of timber sales is carried out by Forest Management Associations. Forest owners can also grant their FMA the power of attorney concerning wood sales and deliveries. The share of attorney services has grown steadily and currently about 40% of timber sales from private forests are based on attorney sales. However, according to the Forest Management Association Act, the Forest Management Associations may not engage in trade by buying or selling harvesting rights or timber for its own account or in any other industrial activity that is not necessary for the implementation of the function and tasks of the Forest Management Association.

Because intermediary agents purchasing wood and re-selling it to forest industry companies are almost nonexistent in Finland, the big forest industry companies purchase the majority of roundwood directly. The buyer side in the Finnish roundwood market is therefore highly concentrated and for example the share of the three biggest companies in the pulpwood market is 80-90%.

In Finland, the main sale types are:

- Standing sales: Standing sale is the main sale type in Finland, where 87% of Scots pine sawlogs and 68% of pulpwood trades were standing sales in 2009. The buyer is responsible for the harvesting of timber, hauling of logs to the forest road side and transporting timber assortments to production plants.
- Roadside sales: In roadside sales the seller commits to delivering the agreed amounts of timber assortments to roadside. The seller is responsible for harvesting and the price of the timber includes harvesting costs. About 50% of harvesting and 2/3 of forest hauling is conducted by professional conductors.
- Delivered sales: Delivered sales are practiced in Metsähallitus and in some commonhold forests. They deliver the wood and sell it to customers via its own organization; that is, they transport the harvested timber directly to the customer’s premises. Wood is delivered to customers in the agreed dimensions and grades and at the appointed time and place. The amounts of delivered sales outside Metsähallitus are negligible.

In standing sales, the amount of timber is usually measured during harvesting by the harvesters measurement unit. The share of harvester measured timber in standing sales was 97.6 % in 2009

(Melkas 2009). 1.8 % of timber was measured at the mill, 0.5% at the roadside and 0.1% was measured by weight scale measurements. From all roadside and delivery sales 40.1% was measured at the mill, 31.0% by the harvester, 27.6% was measured at the roadside and 1.3% was measured by weight scale measurements (Melkas 2009).

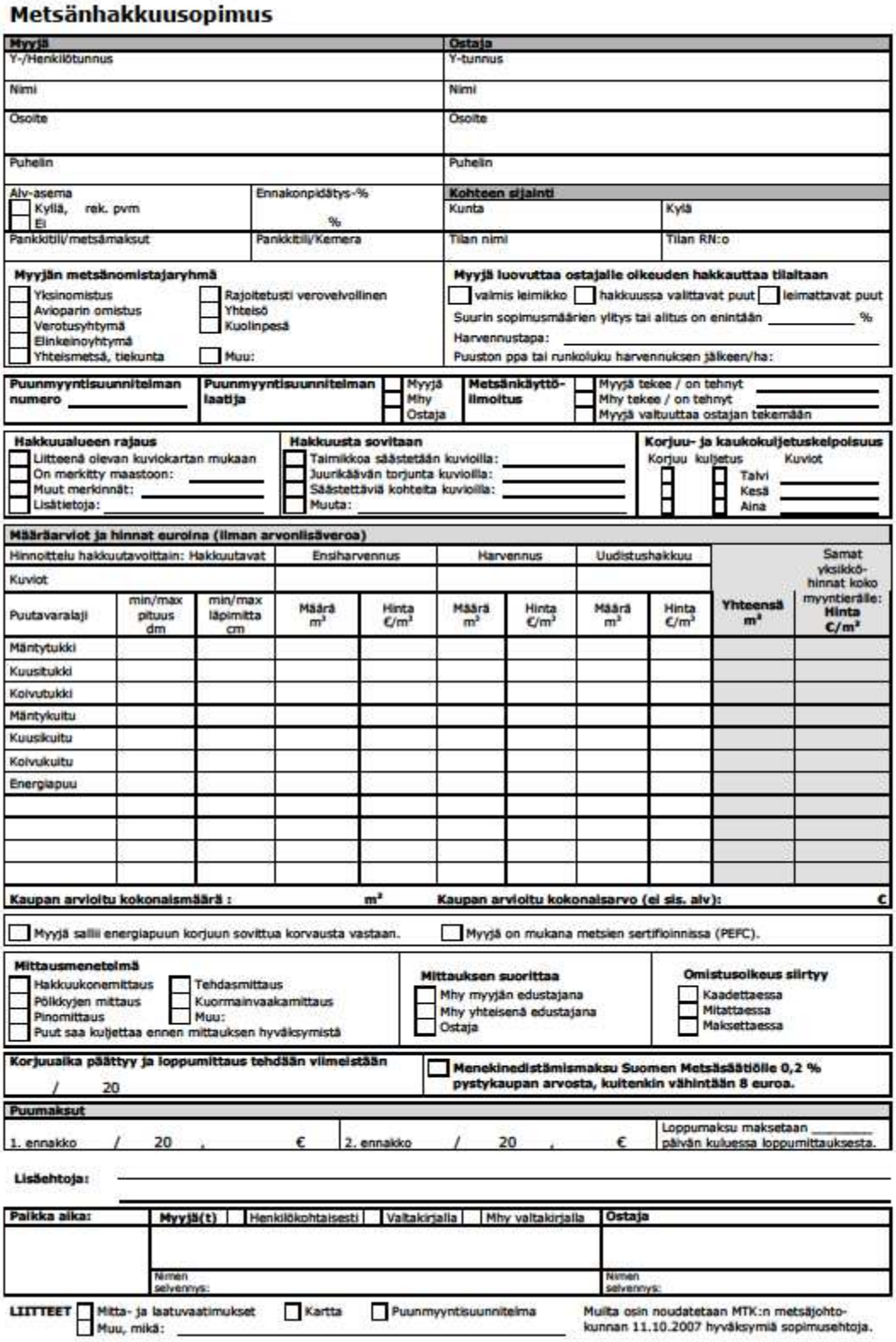
In Finland, roundwood pricing is mainly based on unit prices for different timber assortments (figure 2). The unit prices are based on the price negotiations between the buyer and the seller, indicated in euros per solid cubic metre with bark. When entering into a contract, the buyer and the seller agree on the terms and conditions of the transaction, e.g. on the dimensions of the various assortments (e.g. minimum top diameter and lengths) and quality (allowed knot sizes, sweep and defects). Typical dimensional and quality requirements of Scots pine assortments in Finland are:

1. **Pine sawlogs**
   - minimum top diameter 15 cm, on bark
   - sound knots no more than 6 cm and dry knots 4 cm in diameter
   - sharp crooks or multiple crooks not allowed
   - rot, blue stain or worm holes not allowed

2. **Pine pulpwood**
   - minimum top diameter 6 cm or 7 cm on bark
   - maximum diameter agreed upon case by case
   - hard rot and stain are allowed
   - surface or storage rot not allowed
   - crooks, abnormalities and branch bolts are not allowed

In addition to assortment pricing, some independent saw mills are buying timber using alternative pricing mechanisms. Recently, a pricing mechanism called stem pricing has gained ground. In stem pricing, the sold roundwood has one unit price despite the timber assortment cut from the stems. Other alternative pricing mechanisms used in Finland are: fractional stem pricing, where stems are divided into value fraction according to the diameter; price list pricing, where each saw timber quality and log length-diameter class has its own price; and quality based assortment pricing, where timber assortment unit prices are weighted by estimated quality or log dimensions. However, the share of these pricing mechanisms is marginal.

Figure 1. Pile of Scots pine pole logs at the mill yard.



Metsänhakkuusopimus

Myyjä		Ostaja	
Y-/Henkilötunnus		Y-tunnus	
Nimi		Nimi	
Osoite		Osoite	
Puhelin		Puhelin	
Alv-asema ☐ Kyllä, rek. pvm ☐ Ei	Ennakonpidätys-% %	Kohteen sijainti: Kunta	Kylä
Pankkitili/metsämaksut	Pankkitili/Kemera	Tilan nimi	Tilan RN:o

Myyjän metsänomistajaryhmä
☐ Yksinomistus ☐ Avioparin omistus ☐ Verotusyhtymä ☐ Elinkeinoyhtymä ☐ Yhteismetsä, tiekunta ☐ Rajoitetusti verovelvollinen ☐ Yhteisö ☐ Kuolinpesä ☐ Muu:

Myyjä luovuttaa ostajalle oikeuden hakkauttaa tilaltaan
☐ valmis leimikko ☐ hakkuussa valittavat puut ☐ leimattavat puut
Suurin sopimusmäärien ylitys tai alitus on enintään _____ %
Harvennustapa: _____
Puuston ppa tai runkoluku harvennuksen jälkeen/ha:

Puunmyyntisuunnitelman numero	Puunmyyntisuunnitelman laatija		Metsänkäyttöilmoitus	
_____		☐ Myyjä ☐ Mhy ☐ Ostaja		☐ Myyjä tekee / on tehnyt _____ ☐ Mhy tekee / on tehnyt _____ ☐ Myyjä valtuuttaa ostajan tekemään

Hakkuualueen rajaus
☐ Liitteenä olevan kuviokartan mukaan
☐ On merkitty maastoon: _____
☐ Muut merkinnät: _____
☐ Lisätietoja: _____

Hakkuusta sovitaan
☐ Taimikkoa säästetään kuvioilla: _____
☐ Juurikäävän torjunta kuvioilla: _____
☐ Säästettäviä kohteita kuvioilla: _____
☐ Muuta: _____

Korjuu- ja kaukokuljetuskelpoisuus
Korjuu ☐ kuljetus ☐ Kuviot ☐ Talvi _____ ☐ Kesä _____ ☐ Aina _____

Määräarviot ja hinnat euroina (ilman arvonlisäveroa)

Hinnoittelu hakkuutavoittain: Hakkuutavat			Ensiharvennus		Harvennus		Uudistushakkuu			Samat yksikköhinnat koko myyntierälle:
Kuviot										
Puutavaralaji	min/max pituus dm	min/max läpimitta cm	Määrä m³	Hinta €/m³	Määrä m³	Hinta €/m³	Määrä m³	Hinta €/m³	Yhteensä m³	Hinta €/m³
Mäntytukki										
Kuusitukki										
Koivutukki										
Mäntykuitu										
Kuusikuitu										
Koivukuitu										
Energiapuu										

Kaupan arvioitu kokonaismäärä : _____ m³ **Kaupan arvioitu kokonaisarvo (ei sis. alv):** _____ €

☐ Myyjä sallii energiapuun korjuun sovittua korvausta vastaan. ☐ Myyjä on mukana metsien sertifioinnissa (PEFC).

Mittausmenetelmä
☐ Hakkuukonemittaus ☐ Pölkkyjen mittaus ☐ Pinomittaus ☐ Tehdasmittaus ☐ Kuormainvaakamittaus ☐ Muu:
☐ Puut saa kuljettaa ennen mittauksen hyväksymistä

Mittauksen suorittaa
☐ Mhy myyjän edustajana ☐ Mhy yhteisenä edustajana ☐ Ostaja

Omistusoikeus siirtyy
☐ Kaadettaessa ☐ Mitattaessa ☐ Maksettaessa

Korjuualka päättyy ja loppumittaus tehdään viimeistään
_____ / 20

☐ **Menekinedistämismaksu Suomen Metsäsäätiölle 0,2 % pystykaupan arvosta, kuitenkin vähintään 8 euroa.**

Puumaksut

1. ennakko	/ 20 ,	€	2. ennakko	/ 20 ,	€	Loppumaksu maksetaan _____ päivän kuluessa loppumittauksesta.

Lisäehtoja: _____

Paikka aika:	Myyjä(t) ☐ Henkilökohtaisesti ☐ Valtakirjalla ☐ Mhy valtakirjalla	Ostaja
	Nimen selvennys:	Nimen selvennys:

LIITTEET ☐ Mitta- ja laatuvaatimukset ☐ Kartta ☐ Puunmyyntisuunnitelma ☐ Muu, mikä: _____

Muilta osin noudatetaan MTK:n metsäjohtokunnan 11.10.2007 hyväksymiä sopimusehtoja.

Figure 2. Example of standing sales contract in Finland. (The Central Union of Agricultural Producers and Forest Owners (MTK))

2.2 Norway

In Norway, the forests are owned by private forest owners (80%), state and municipalities (12%) and industrial private owners (4%). The rest is local common land (Forests in Norway 2010). The forestry in Norway is being managed and operated through typical small-scale forestry operations. Most of the harvesting is done by mechanised systems operated by professional harvesting contractors.

In the 1990s, approximately 15% of forest owners or family members were actively engaged in their forest through felling and/or transporting operations, but these days the owners might do some silvicultural management (planting, pre-commercial thinning), greatly helped by beneficial tax rules. This new situation has affected the roundwood supply since earlier forest owners strive to have a stable workload, and consequently supply logs every year. Nowadays the roundwood market acts more like markets for other capital goods; expected price changes are often more influential than the price itself. When the forest owner expects a price drop, he will put as many logs as possible into trade and vice versa.

Norges Skogeirforbund (NSF, The Norwegian Forest Owners' Federation), together with its regional associations, is the main forest owner association in Norway. The regional association assists forest owners in the long-term and operational-level planning, timber marketing and also organises harvesting operations on behalf of forest owners. In total, regional forest owners' associations conduct about three-quarters of all timber sales in Norway. In most cases, forestry operations are carried out by contractors and usually under the supervision of a regional forest owners' association or industry (timber procurement departments).

The chronology of NSFs timber purchasing-selling process is as follows (Størdal 2004):

1. A regional NSF negotiates with an individual or groups of forest industry firms regarding a timber supply agreement. The price is set for different seasons each year (e.g., winter, summer and fall). This agreement is mainly related to the price of various species and assortments (figure 3) according to matrices concerning stem-diameter and length. Generally there is no agreement concerning quantities.
2. A forest owner notifies the NSF of his planned harvesting schedules, which in turn plans transport and distribution of timber to the different mills.
3. The NSF develops a set of contracts for its members. The ''spot'' contract relates to supplies of specific timber lots at a future date, and is the point of departure for other types of contracts. The spot price is the minimum price paid to the forest owners.
4. The forest owner decides whether to harvest or not, and whether to enter other obligations in order to receive price premiums (bonus agreements).
5. The FOA (Forest Owners Association) pays the forest owners according to their timber deliveries and price list and bonus arrangements.

Sagtømmer- og massevirkeprisene i 2010.

Oppdatert 08.02.10 Svein Haare og Ivar Stuve

Tømmerpriser

Massevirke, kr pr. m³

	Termin 1 - 4 (januar - april)
Gran prima	240,-
Furu prima	200,-
Energigran	200,-
Biovirke	140,-
Tynningsvirke gran *)	250,-
Tynningsvirke furu	215,-

*)For å oppnå tynningsprisen må også sagtømmeret i partiet leveres som sort. 114 massevirke, gran.

Sagtømmer **)

	Termin 1 - 4 (januar - april)
Prisnivå gran	440,- – 480,-
Prisnivå furu	420,- – 500,-

**) Sagtømmerprisene er kjøpervise og avhengig av flere forhold, slik som skogtype og aptering. Og ovennevnte priser er derfor å anse som veiledende. For å få så nøyaktig angivelse av pris som mulig må skogeier kontakte skogbruksleder, som kan besiktige det aktuelle bestandet og/eller oversende aktuell prisliste til skogeier.

I tillegg til prisene ovenfor (massevirke og sagtømmer)gjelder:

Storleverandørbonus

Med virkning fra 1.1.2010 blir storleverandørbonusen som følger:

For leverandører som leverer mellom 1200 og 1999 m3: **15 kr/m3 ekstra.**
For leverandører som leverer 2 000 m3 eller mer: **30 kr/m3 ekstra.**

Storleverandørbonusen betales fra første m3.

Eierskiftetillegg

Tillegget overfor ny eier ved eierskifte videreføres. Merprisen er **10 kr/m³**, og gjelder leveranser i ett år etter tinglyst eierskifte. Tillegget gjelder kun andelseiere i Viken Skog.

FSC-tømmer

For tømmerleverandører som er FSC-godkjent, utbetales et tillegg på 45 kr/m3. Dette tillegg gjelder inntil videre for gran massevirke til Hellefoss AS og gran sagtømmer til Begna Bruk AS, innenfor et gitt kvantum.

Figure 3. Example of sawlog and pulpwood prices in forest owners' regional association Viegen Skog. (Viken Skog 2010)

Sawlog prices are given in NOK per nominal co. metre (see chapter 5.6). In some cases, participants find this standard price list not flexible enough; e.g. due to customer preference, technical equipment or other, some logs might be more valuable - and others less valuable - as raw material. Consequently, it is a well established practice to agree on specific price matrices (figure 4). Certain wanted combinations of length - diameter - quality are given a raised price to stimulate bucking/cross-cutting. For other combinations, the price is lowered to indicate they are less attractive

.

Prisliste FRIK

Diametre top end, cm \ Length, dm	34	37	40	43	46	49	52	55	58	61
13	220	235	250	280	310	400	400	370	250	250
14	220	265	280	280	310	400	400	310	310	310
15	250	295	325	400	460	490	490	460	310	310
16	220	265	295	340	415	445	445	415	310	310
17	250	295	325	400	460	490	490	460	370	310
18	220	265	295	340	415	445	445	415	370	310
19	220	265	295	340	415	445	445	415	370	310
20	250	295	325	400	460	490	490	460	370	310
21	220	265	295	340	415	445	445	415	370	310
22	220	265	295	340	415	445	445	415	370	310
23	220	265	295	340	415	445	445	415	370	310
24	220	265	295	340	415	445	445	415	370	310
25	220	265	295	340	415	445	445	415	370	310
26	235	295	325	400	460	490	490	460	370	310
27	220	265	295	340	415	445	445	415	370	310
28	235	295	325	400	460	490	490	460	370	310
29	235	355	370	400	460	490	490	460	430	310
30	220	355	370	310	325	340	340	430	430	310
31	220	355	370	310	325	340	340	430	430	310
32	220	355	370	310	325	340	340	430	430	310
33	220	355	370	310	325	340	340	430	430	310
34	220	355	370	310	325	340	340	430	430	310
35	220	355	370	280	295	325	325	430	430	310
36	220	355	370	280	295	325	325	430	430	310
37	220	265	280	280	295	325	325	295	295	310
38	220	220	235	243	250	280	280	250	250	250
39	220	220	235	243	250	280	280	250	250	250
40	220	220	235	243	250	280	280	250	250	250

Prisliste ROT

Diametre top end, cm \ Length, dm	34	37	40	43	46	49	52	55	58	61
13	220	265	280	280	310	400	400	310	310	310
14	250	295	325	400	460	490	490	460	310	310
15	220	265	295	340	415	445	445	415	310	310
16	250	295	325	400	460	490	490	460	370	310
17	220	265	295	340	430	460	460	430	370	310
18	220	265	295	340	430	460	460	430	370	310
19	220	265	295	340	430	460	460	430	370	310
20	220	235	250	265	295	325	325	310	280	280
21	220	235	250	265	295	325	325	310	280	280
22	220	265	295	340	430	460	460	430	370	310
23	220	265	295	340	430	460	460	430	370	310
24	250	295	325	430	460	490	490	490	370	310
25	220	265	295	340	430	460	460	430	370	310
26	220	265	295	340	430	460	460	430	370	310
27	235	295	325	340	460	490	490	460	370	310
28	235	355	370	340	460	490	490	460	430	310
29	220	355	370	310	325	340	340	430	430	310
30	220	355	370	310	325	340	340	430	430	310
31	220	355	370	310	325	340	340	430	430	310
32	220	355	370	310	325	340	340	430	430	310
33	220	355	370	310	325	340	340	430	430	310
34	220	355	370	280	295	325	325	430	430	310
35	220	355	370	280	295	325	325	430	430	310
36	220	265	280	280	295	325	325	295	295	310
37	220	220	235	243	250	280	280	250	250	250
38	220	220	235	243	250	280	280	250	250	250
39	220	220	235	243	250	280	280	250	250	250
40	220	220	235	243	250	280	280	250	250	250

Figure 4. Price lists, examples for two different quality assortments; FRIK (green knots) logs are found in the upper parts of a trunk, while ROT is the butt log. Green colour indicates that the price is raised, yellow and red that the price is lowered (Gjerdrum 2009)

Grading and timber measurements for roundwood trade are usually executed by Norsk Virkesmåling (Timber Grading Association). Timber Grading Association is an association of sellers and buyers of forest products with the objective to execute grading and scaling of roundwood and chips.

Sawlogs are measured and priced individually, based on the log's length, top end diameter and quality. By log grading, sawlogs are classified into quality classes. If the buyer and the seller have not agreed upon other dimension requirements, the following applies:

Table 1. Dimensions requirements for sawlog quality classes (Grading and scaling regulations for coniferous sawlogs 1998).

	Quality class		
	1. Special	2. First class	3. Second class
Minimum top-diameter (ub)	22 cm	12 cm	12 cm
Maximum diameter (ub)	60 cm	60 cm	60 cm
Minimum length	34 cm	34 cm	34 cm
Maximum length	58 cm	58 cm	58 cm

For detailed description of sawlog quality requirements, see Grading and scaling regulations for coniferous sawlogs (1998). However, partners may agree on specific tolerances for their trade, in which case a company specific tolerance table is usually adapted to the market situation for the sawmill in question.

2.3 Scotland

In Scotland, softwood timber is generally sold using one of the following three pricing mechanisms:

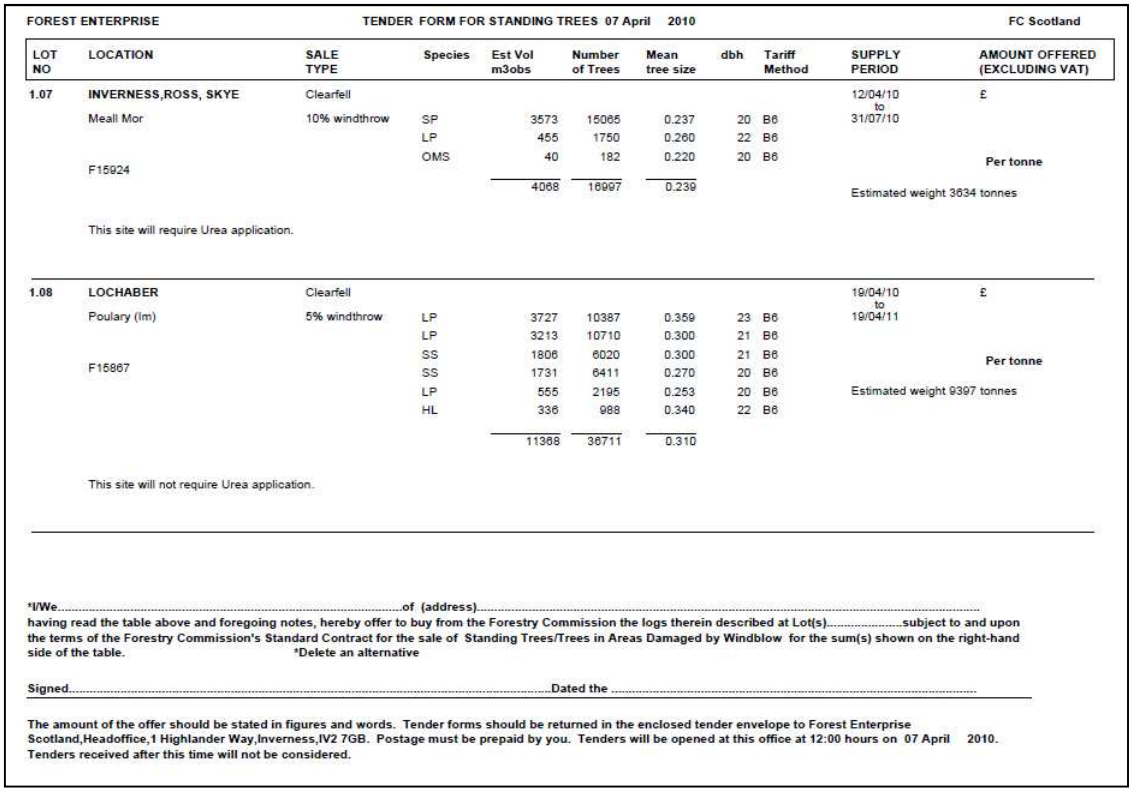
- Standing sales: The buyer is responsible for the harvesting of timber, hauling of logs to the forest road side and transporting assortments to production plants. The terms and conditions for the sale are agreed between the seller and the buyer, which includes conditions on the buyer relating to health and safety on the worksite, environmental standards, timing of the operation, transporting of timber and methods of payment or credit arrangements. Standing sales is the most common roundwood trading type. In the Highland and Grampian regions 69% is traded using standing sales (Macdonald & Gardiner 2007).
- Roadside sales: In roadside sales the seller sells logs of a given specification “at roadside”. The specification will normally be based on log grade, “green” (higher quality) or “red” (lower quality) in accordance with Forestry Commission Field Book 9 (Classification of… 1993) and dimensions, log length and top diameter. The buyer is responsible for transporting the logs from the forest roadside.
- Delivered sales: In delivered sales the seller is responsible for harvesting, hauling of logs to roadside and delivery of logs to the production plant. This type of sale is the most common for small roundwood delivered to production plants making panel boards or paper.

The quantity and actual price of standing sales can be agreed in the following three ways:

- Lump sum: In this type of sale the seller and the buyer agree a price to be paid for all the timber to be harvested from a given area, defined on a map and usually on the ground by paint or tape. In thinnings all the trees to be harvested would be marked. A lump sum can be on the basis of measured volume using a “full tariff” when the price is per cubic meter for the measured total volume. In this method the seller provides a detailed count of all the trees in the sale, diameter distribution and volume sample information.
- Weight sale, average price per tonne: This is the most widely used pricing mechanism for standing sales in Scotland. A price per tonne is agreed for all timber removed from

the sale area, irrespective of the type of timber assortment. Payment is based on weights of timber delivered to the sawmill or factory (figures 5 and 6).

- Weight sale, price per product: This is similar to an average price weight sale but a separate price is agreed and paid for each category of log.



FOREST ENTERPRISE — TENDER FORM FOR STANDING TREES 07 April 2010 — FC Scotland

LOT NO	LOCATION	SALE TYPE	Species	Est Vol m3obs	Number of Trees	Mean tree size	dbh	Tariff Method	SUPPLY PERIOD	AMOUNT OFFERED (EXCLUDING VAT)
1.07	INVERNESS,ROSS, SKYE	Clearfell							12/04/10 to 31/07/10	£
	Meall Mor	10% windthrow	SP	3573	15065	0.237	20	B6		
			LP	455	1750	0.260	22	B6		
			OMS	40	182	0.220	20	B6		Per tonne
	F15924			4068	16997	0.239			Estimated weight 3634 tonnes	
	This site will require Urea application.									
1.08	LOCHABER	Clearfell							19/04/10 to 19/04/11	£
	Poulary (lm)	5% windthrow	LP	3727	10387	0.359	23	B6		
			LP	3213	10710	0.300	21	B6		
			SS	1806	6020	0.300	21	B6		Per tonne
	F15867		SS	1731	6411	0.270	20	B6		
			LP	555	2195	0.253	20	B6	Estimated weight 9397 tonnes	
			HL	336	988	0.340	22	B6		
	This site will not require Urea application.			11368	36711	0.310				

*I/We.....of (address).....
having read the table above and foregoing notes, hereby offer to buy from the Forestry Commission the logs therein described at Lot(s).....subject to and upon the terms of the Forestry Commission's Standard Contract for the sale of Standing Trees/Trees in Areas Damaged by Windblow for the sum(s) shown on the right-hand side of the table. *Delete an alternative

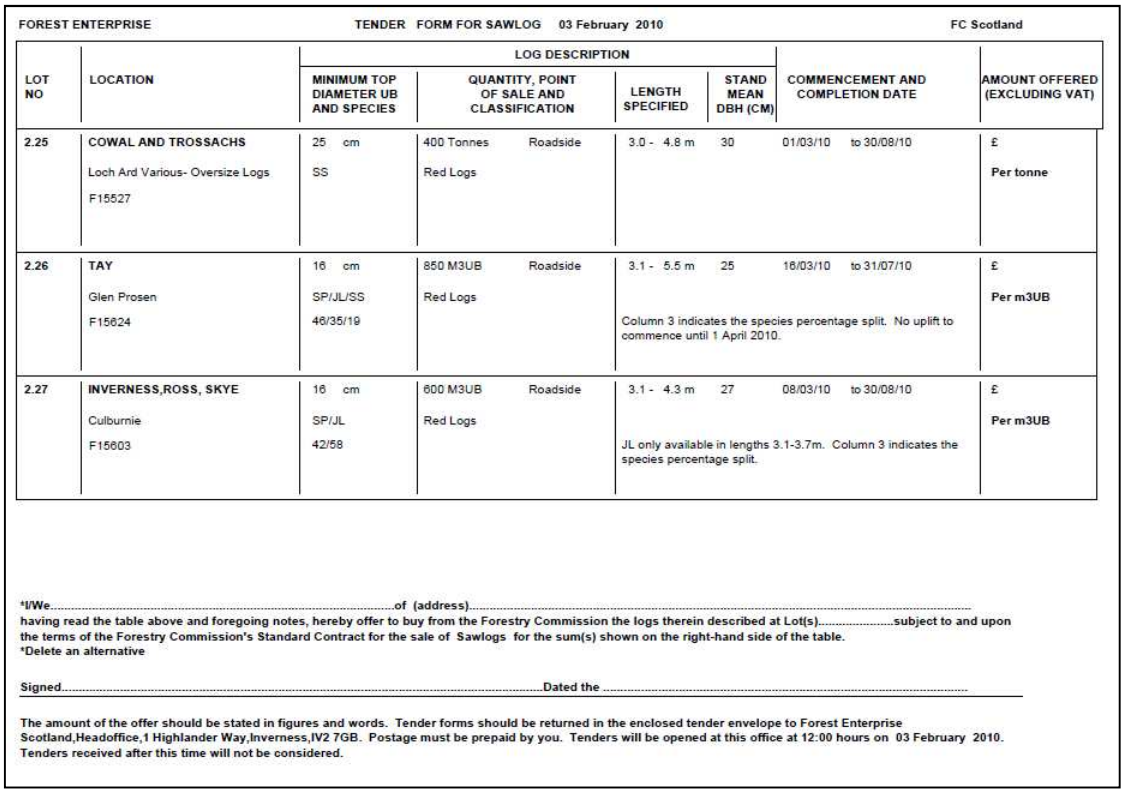
Signed.....Dated the .....

The amount of the offer should be stated in figures and words. Tender forms should be returned in the enclosed tender envelope to Forest Enterprise Scotland,Headoffice,1 Highlander Way,Inverness,IV2 7GB. Postage must be prepaid by you. Tenders will be opened at this office at 12:00 hours on 07 April 2010. Tenders received after this time will not be considered.

Figure 5. Example of Forestry Commission Scotland's tender form for two clear felling stands in Scotland. Both stands are pre-measured and the price will be based on average price per tonne.

Roadside sales are agreed using either price per tonne or per cubic metre (figure 6). When the price is per tonne, sawmill weight measurements are used as the basis for pricing. When the price is per cubic metre, the volume per load is normally calculated from the weighbridge weight, using a conversion factor agreed from a sample load for each batch of 10-20 loads. The conversion factor is either calculated from log volumes from a sawmill scanner (most common nowadays) or from log volumes from a manual measurement of all the logs in a sample load. Delivered sales are usually priced per tonne delivered.

In Scotland, each forest owner decides how to best market their timber. Forestry Commission, responsible for harvesting 51% of all softwood timber produced in UK, uses a mixture of standing and roadside sales, marketing timber through some long term contracts and some competitive sales. In the private sector, sale methods vary greatly. Some private sector sellers have long standing relationships with buyers, others invite tenders from local buyers, while some may advertise.



FOREST ENTERPRISE — TENDER FORM FOR SAWLOG 03 February 2010 — FC Scotland

LOT NO	LOCATION	LOG DESCRIPTION: MINIMUM TOP DIAMETER UB AND SPECIES	LOG DESCRIPTION: QUANTITY, POINT OF SALE AND CLASSIFICATION	LOG DESCRIPTION: LENGTH SPECIFIED	LOG DESCRIPTION: STAND MEAN DBH (CM)	COMMENCEMENT AND COMPLETION DATE	AMOUNT OFFERED (EXCLUDING VAT)
2.25	COWAL AND TROSSACHS Loch Ard Various- Oversize Logs F15527	25 cm SS	400 Tonnes Roadside Red Logs	3.0 - 4.8 m	30	01/03/10 to 30/08/10	£ Per tonne
2.26	TAY Glen Prosen F15624	16 cm SP/JL/SS 46/35/19	850 M3UB Roadside Red Logs	3.1 - 5.5 m Column 3 indicates the species percentage split. No uplift to commence until 1 April 2010.	25	16/03/10 to 31/07/10	£ Per m3UB
2.27	INVERNESS,ROSS, SKYE Culburnie F15603	16 cm SP/JL 42/58	600 M3UB Roadside Red Logs	3.1 - 4.3 m JL only available in lengths 3.1-3.7m. Column 3 indicates the species percentage split.	27	08/03/10 to 30/08/10	£ Per m3UB

*I/We.....of (address).....
having read the table above and foregoing notes, hereby offer to buy from the Forestry Commission the logs therein described at Lot(s).....subject to and upon the terms of the Forestry Commission's Standard Contract for the sale of Sawlogs for the sum(s) shown on the right-hand side of the table.
*Delete an alternative

Signed.....Dated the .....

The amount of the offer should be stated in figures and words. Tender forms should be returned in the enclosed tender envelope to Forest Enterprise Scotland,Headoffice,1 Highlander Way,Inverness,IV2 7GB. Postage must be prepaid by you. Tenders will be opened at this office at 12:00 hours on 03 February 2010. Tenders received after this time will not be considered.

Figure 6. Example of Forestry Commission Scotland's tender of three roadside roundwood stocks in Scotland. Two of the stocks are price per cubic meter under bark and third one is priced per tonne.

2.4 Sweden

In Sweden, there are four different types of roundwood trade (Development of…2009):

- Standing sales (rotpost): All the trees to be harvested within the felling area are marked and measured beforehand. According to the list of marked trees the amount of roundwood is calculated and the final price is agreed before harvesting. The buyer is responsible for the harvesting, hauling the logs to roadside and transportation of logs to production plants.
- Roadside sales (leveransvirke): The seller and the buyer agree on a price list to be applied in the transaction. The forest owner is responsible for harvesting and hauling of the timber to road side. The buyer transports the logs to production plants where the roundwood is measured by a regional Virkesmätningsförening (Timber Grading Association), VMF, to define the final value of the trade.
- Cutting commission (avverkningsuppdrag): The volume of the trade is not specified, but is measured after harvesting at the production plant by VMF. The buyer and the seller agree on a price list applied in the roundwood trade. The buyer is responsible for the harvesting, hauling and transportation of roundwood. The buyer's costs (real or estimated) for harvesting and transportation are deducted from the final payment.
- Delivery standing sales (leveransrotköp): Roundwood is sold as stumpage and the net price in the contract is either per assortment or the total average price per m^3sub (solid under bark). The seller conducts harvesting and transportation, and the payment is made

after measurements made by regional VMF at the measurement stations located at the production plants.

In most cases, roundwood measurements are conducted at the production plant by the regional VMF. VMS are regional non-governmental organization where buyers and sellers of timber in the Swedish market are equally represented. Sawlogs are measured in $m^3$to (top-end cylinder without bark) and pulpwood is priced m^3fub (solid volume under bark). Sawlogs are priced according to price lists, where each diameter-length class has its own value (figure 7). Each quality, four for Scots pine, has its own pricing. There are no quality classes for pulpwood.

Sågtimmer Tall

Kr/$m^3$to ub

Toppdiam (cm)	12-	13-	14-	16-	18-	20-	22-	24-	26-	28-	30-
Klass 1	494	580	662	741	809	871	922	962	992	1007	1010
Klass 2	466	548	628	690	695	700					
Klass 3	435	449	482	525	571	626	632	642	647	650	652
Klass 4	408	413	428	454	492	507	516	522	524	527	530

Längdkorrektion kr/$m^3$to ub, diameterberoende

För 12 och 13 cm avgår ingen längdkorrektion, detta för att säkerställa ett medelpris över massavedspriset.

Längd (dm)	31-	34-	37-	40-	43-	46-	49-	52-	55-
14-16 cm	-95	-75	-55	-40	-20	0	10	25	30
16-19 cm	-85	-65	-45	-25	-10	0	10	25	30
20+ cm	-70	-50	-30	-20	-10	0	10	20	25

Apteringspremie

SCA anpassar vid avverkningstillfället timret efter längdönskemål från sågverkets kunder. Därför ingår i grundprismatrisen apteringspremie med 15 kr/m3to. Premien särredovisas vid slutreglering.

Kr/$m^3$to omräknat till kr/m^3fub

enligt kalkylmässiga toppformat, 46 dm

Toppdiam (cm)	12-	13-	14-	16-	18-	20-	22-	24-	26-	28-	30-
Klass 1	412	483	552	618	680	732	781	815	848	861	863
Klass 2	340	400	476	539	551	564					
Klass 3	351	362	395	438	480	526	535	544	553	555	557
Klass 4	314	318	340	369	406	423	434	442	448	450	453

Dimensioner:

Diameter 14–60 cm (12, 13 cm i mån av avsättning och prisförutsättning).
Längd 34–55 dm (i mån av avsättning och prisförutsättning kan andra längder förekomma).

Figure 7. Swedish price list for Scots pine. The first table stands for values for different quality classes (Klass 1-4) and top diameters in $m^3$to, the second table stands for length correction for different diameter classes and lengths and the third table stands for values of first table converted to values in m^3fub.

The main pricing mechanism in Sweden is the price lists published by the forest owners' associations. The price lists consist of a base price at different premiums. An association's pricing power depends on the local circumstances. A higher degree of membership in the region's association may gain a more dominant role and hence more influence on the price level. The price lists of forest owners' associations are usually concerned with a minimum price level. Depending on the circumstances, the buyers pay the price listed or above due to premiums depending on demand, season, special assortment or buyer's strategic consideration.

In general, Swedish roundwood markets are based on individual contacts between sellers and buyers. However, private forest owners can co-operate through the Forest Owner Associations. The Forest Owner's Associations assist their members in forest management planning (both on a long-term level and on an operational level), timber marketing and in undertaking silvicultural operations such as planting, thinning, harvesting, etc. However, the membership in a forest owners' association does not oblige the forest owner to sell the roundwood to the association.

3 Requisites for pricing mechanisms

3.1 Demands from roundwood markets

According to the simplest definition of market efficiency, the price of the product reflects the available demand and supply; thus buying or selling should, on average, return a "fair" measure of return for the associated risk. However, the roundwood markets are characterized by asymmetric market information, where the wood buyer or wood procurement company has inside information on the product: processing values, assortment recoveries, etc.

The optimal pricing mechanism for roundwood trade should include the following aspects:

- Pricing mechanism should not restrict value optimization of raw material.
- Pricing mechanism should be transparent and easy to understand.
- Pricing mechanism should offer incentives to grow higher quality raw material.

The optimal pricing mechanism is related to sale type (standing sales, roadside sales or delivered sales) and measurement of raw material. In the ideal situation, we would have full knowledge of the properties of stand and stems, and the volumes and properties of possible timber assortments cut from the stand. However, this is not the case in the real world. We can have pre-information from the stand and stem properties, but this kind of information is usually laborious and expensive to achieve, and the possibility of measurement and estimation errors still exists. Assortment volumes are easy to achieve during harvesting, but this information is not available before cutting the stems, and the possibilities to estimate the quality of the timber are restricted. The measurements made at the roadside or at the mill offer possibilities to also measure the quality of the trees, but the measurements are laborious and therefore costly. Following from this, the optimal pricing mechanism should be flexible for different harvesting outcomes giving a fair price even in the situations where the outcome is not predictable before trade.

The three requisites of roundwood pricing mechanisms have different time scales for forestry. The requisite for the pricing mechanism to not restrict value optimization of raw material is a short term decision. The requisite for the pricing mechanism to be transparent and easy to understand affects the choice whether to harvest or not and what kind of stands are traded in the markets and who will win the bidding. The third requisite, the pricing mechanism should offer incentives to grow higher quality raw material, influences long term decision making, e.g. issues such as the type of silvicultural practices being carried out, or how much the forest owner is willing to invest into the forest.

3.2 Value optimisation of raw material

Nowadays most sawmills are selling their production beforehand and the raw material acquisition should meet the needs of the sold production, that is, the amount of species, timber assortment, their quality and log length-diameter distribution should match the demand as closely as possible. Each log producing unsold sawn timber will be the headache of the marketing department.

Nowadays modern harvesters are able to estimate the tapering of the felled stem, calculate the possible bucking combinations and select the optimal bucking combination according to the price and demand matrices which define the value and relative demand for quality and log dimension by timber assortments. This bucking-to-demand (or bucking-to-order) procedure allows sawmills to steer the log length-diameter distribution towards the desired one as long as the minimum lengths and diameters are as stated in the contract. However, there are situations when the agreed timber assortments or minimum dimensions are not optimal. For example, in Finland, the standing sale contract can be made as early as two years before harvesting. Market demands between the time of the contract and of the actual harvesting may have changed significantly. If the contract defines what has to be cut from the stand it may lead to unwanted raw material or even a conflict between the timber buyer and the forest owner.

3.3 Transparency and understandability

Many countries have different organisations and enterprises offering help for roundwood trade or even conducting negotiation on behalf of the forest owner. This is due to the situation where forest owners are unable to decide which buyer is paying the best price for their timber. This is the outcome of heterogeneous raw material and exceedingly complicated pricing mechanisms. There are studies (Hubbard & Abt, 1989, Larson & Hardie, 1989) which show that the forest owner's net revenue is more correlated with the processing value of roundwood if the forest owner is assisted by a consultant. However, assistance did not increase net revenue from low-valued stands.

The demand for transparency and understandability would be easy to fulfil by treating raw material as a homogenous material, where the buyer buys roundwood as per volume or per weight. This approach would fulfil the demands for value optimization, but the problem is the absence of incentives to grow high quality timber. Even though the value per volume or weight would vary according to the average size and quality, this would not be transparent for the forest owner and it would be hard to see what kind of benefits the seller would get if the average stem size or quality would be higher.

3.4 Incentives to grow high quality raw material

Forest products are usually classified according to the end-use into two different categories, saw logs and pulpwood, and comparisons between raw material prices are made according to these timber assortments. Most of the pricing mechanisms rely on this classification. If the log exceeds minimum requirements of pulpwood, it is classified as a pulpwood and if the log exceeds the minimum requirements of saw logs, it is classified as a saw log. Although this classification is simple and easy to understand, it does not fully reflect the processing value of raw material.

The added value of raw material is different in the different end-uses. This is the question of market competition or market inefficiency, not a problem of pricing mechanisms. The problem of pricing mechanisms is that if the raw material is valued evenly despite its properties and value in further processing, it does not offer incentives to produce higher quality if there does not exist a higher value timber assortment. This problem is most severe for saw logs, for which the value recovery per m^3 in sawing varies considerably according to log dimensions and

quality (Table 2). Although the unit value of saw logs may vary according to the quality and dimensions of logs, the variation is seldom transparent to the forest owner.

Table 2. Example of relative values in sawing / m^3 for Scots pine timber.

Other saw logs	Length, dm				Class A butt logs	Length, dm			
Top diameter, mm	37	43	49	52	Top diameter, mm	37	43	49	52
150–159	57	67	70	71	150–159	52	64	65	66
160–179	62	72	74	75	160–179	65	74	76	77
180–199	66	77	80	81	180–199	76	87	89	90
200–219	70	82	85	86	200–219	86	98	100	101
220–239	73	85	89	90	220–239	93	107	109	110
240–259	76	89	92	93	240–259	100	114	117	118
260–279	78	91	94	95	260–279	105	120	122	123
280–299	79	92	96	97	280–299	108	123	126	127
300–319	80	93	96	98	300–319	109	125	128	129
320–339	80	93	96	98	320–339	109	125	128	129
340–359	80	93	96	98	340–359	109	125	128	129
360–379	80	93	96	98	360–379	109	125	128	129

Most valuable saw logs, relative value over 110
Relative value 90–110
Relative value under 90

Constant unit prices for timber assortments lead to another problem. Since the unit value of a timber assortment seems to be the same despite the dimensions and quality of saw logs, the economical calculations for the optimal rotation period suggest earlier harvesting times than the processing value would suggest. This leads to a vicious circle: since the optimal rotation period is shorter, the average size of the harvested timber becomes smaller, and this diminishes the ability to pay for the raw material, which, in the end, shortens the optimal rotation period.

4 Performance of typical pricing mechanisms in clear-cutting stands

4.1 Background, material and methods

Berg (2010) studied the performance of different typical pricing mechanisms in the clear-cutting standing sales of Scots pine. The main objective was to examine the effect of five typical pricing mechanisms on sale and processing value recovery. The aim was to recognize the pricing mechanisms which encourage growing for higher quality and do not restrict value optimization of raw material.

In total, 61 pine-dominated study stands were collected by measurements on 656 standing sample trees in a research project "Value formation of timber stands when targeting for alternative end-products in timber harvesting" (Malinen et al. 2006) carried out by Finnish Forest Research Institute. Measurements in each stand were made from 2-5 sample plots, 200-300 m^2each. From each sample plot all trees with the minimum diameter at breast height of 7 cm were measured and graded for the dimensions and external technical quality affecting the bucking operation.

All pines from sample plots were bucked with the bucking simulator (Kilpeläinen 2002) in order to find out the volumes of different timber assortments, log length-diameter distributions and qualities for valuing the harvested stems. In the bucking-to-value simulator, the stem volumes of sample trees from the stump height to the top were calculated using taper curve models based on the tree species, the breast-height diameter, and height of the trees (Laasasenaho 1982). The heights of the stumps were calculated by the stump height models of Laasasenaho (1982) as a function of the tree species and the breast-height diameter. Based on the taper curves, the calculated stump heights, the tree measurements, and the predefined values of different timber assortments, the dynamic programming based bucking simulator generated several cutting alternatives for each stem; calculated the value of each alternative according to the predefined price matrices; and selected the optimal alternative maximising the value of the stem. The volumes by different timber assortments were calculated according to the cutting patterns of the selected alternative.

The bucking simulator calculated the volumes and values of timber assortments for each bolt, stem, sample plot, and stand. While using taper curves, the simulator took into account the dimensions and the measured external defects (e.g., sweep, crooks, branchiness, and scars) of the measured trees. For each timber assortment, possible diameter-length combinations and quality requirements had to be defined. The value relations between timber assortments and their diameter-length combinations were given as a value matrix in the simulator. The stem parts that contained defects were bucked as pulpwood or non-merchantable wood including jump butts, off-cuts, and top-cuts. The stem sections that did not achieve the required dimensions and quality requirements of any timber assortments were classified as non-merchantable wood, that is, wood biomass which can be collected for energy use or left in the forest.

Timber assortments harvested from the stand depend on the objectives and wood usage of the wood procurement company. Three buyer categories were created in order to compare sale and processing values for different wood buyer types (Table 3). The "independent sawmill" category represents a typical small- or medium-scale sawmill buying sawn timber for its own

needs and selling pulpwood to the pulpwood corporation. The “corporation” category represents a large corporation whose sawmilling is volume based production and the main interest is to produce pulp and paper. The third category, “butt log user” is a specialised saw mill whose production aims to produce knot-free high quality sawn timber from grade A butt logs or from grade C butt logs by finger jointing. As an independent sawmill, butt log user sells pulpwood to pulping industry with no profit.

Table 3. Buyer categories and timber assortments to be bought.

Timber assortment	Independent sawmill	Corporation	Butt log user
Saw log	x	x	x
Butt log grade A	x	x	x
Butt log grade C	-	-	x
Small-diameter saw log	x	-	x
Pulpwood	x	x	x

The pricing mechanisms tested were:

- Timber assortment pricing
  - One unit price for each timber assortment
- Weighted timber assortment pricing
  - One unit price for each timber assortment, conventional saw logs are divided into top diameter size groups of +15 cm, +18 cm and +26 cm
- Stem pricing
  - One unit price for all harvested timber
- Fractional stem pricing
  - Stem is divided into fractions according to the diameter. Stem fraction exceeding 26 cm has the highest value and stem fraction exceeding 15 cm has higher value than the rest of the harvested timber exceeding 7 cm.
- Price list pricing
  - Each saw log is priced according to its quality, top diameter and length.
  - Pulpwood has one unit price.

The sale and processing values of the sample trees and stands were calculated according to the achieved bucking results, except for stem pricing, where the actual volume was calculated according to bucking simulations but the estimated timber assortment recoveries were calculated according to the timber assortment recovery models by Malinen et al. (2010). These estimated assortment recoveries were used in setting the stem price for each stand. The sale values were based on the previously mentioned pricing mechanisms and unit prices (Tables 4, 5 and 6). The average sale value in each pricing mechanism was scaled to the same level, that is, the total price for bought timber is the same in each pricing mechanism. This was due to the fact that the actual price is always subject to mutual negotiation and the object of the study was not to show any pricing mechanism to be cheaper or more expensive than the other pricing mechanisms.

Processing values were calculated according to the actual average unit processing values in the Finnish wood processing industries. However, due to the confidential nature of the processing value data, they are not reported as such but presented as “utilities” for sale and processing values. The utility value for each variable (sale value per unit area, sale value per unit volume

(o.b.), processing value per unit area and processing value per unit volume (o.b.)) was set to be 100 on average.

Table 4. Timber assortments, their unit prices and diameter requirements used in the simulations of assortment pricing, weighed assortment pricing and stem pricing.

Assortment	Unit price, e/m^3	Minimum top diameter, cm	Minimum length, dm	Maximum length, dm
Butt log grade A	63.00	21	28	61
Butt log grade C	55.00	28	28	58
Saw log +15	50.00	15	37	61
Saw log +18	55.00	18	37	61
Saw log +26	57.00	26	37	61
Saw log	55.00	15	37	61
Small-diameter sawlog	27.00	12	28	49
Pulpwood	15.71	7	28	52

Table 5. Example of price list (€/m^3) used in the price list pricing.

Length,	Log top diameter, mm											
dm	150	160	180	200	210	220	240	260	280	300	320	340
37	36.48	38.98	41.48	43.98	45.46	47.57	51.59	55.33	58.50	60.79	61.15	61.33
40	37.21	39.68	42.15	44.63	46.01	48.14	52.16	55.83	59.42	61.25	61.56	61.71
43	37.83	40.28	42.73	45.18	46.51	48.65	52.67	56.26	59.86	61.66	61.92	62.05
46	38.40	40.83	43.25	45.68	46.96	49.10	53.13	56.66	60.26	62.03	62.24	62.34
49	38.92	41.32	43.73	46.13	47.37	49.52	53.54	57.01	60.62	62.37	62.53	62.62
52	39.39	41.78	44.16	46.54	47.74	49.90	53.92	57.33	60.95	62.67	62.80	62.86
55	39.83	42.20	44.56	46.93	48.09	50.25	54.26	57.63	61.25	62.95	63.04	63.09
58	40.51	42.85	45.19	47.53	48.62	50.79	54.81	58.10	61.85	63.39	63.43	63.45
61	41.07	43.38	45.70	48.02	49.05	51.24	55.25	58.48	62.28	63.75	63.74	63.74

Table 6. Prices for stem fractions and diameter requirements used in the simulations of fractional stem pricing.

Assortment	Unit price, e/m^3	Minimum top diameter, cm	Log lengths, dm
Sawlog +15	48.00	15	37 - 61
Sawlog +26	55.40	26	37 - 61
Pulpwood	15.00	7	28 - 52

The sale values were calculated for the total stem volumes (o.b.), depicting the net income of the forest owner including all assortments which were bucked. However, the processing values in buyer categories of “independent sawmill” and “butt log user” were calculated only for the assortments of mechanical wood industries, i.e. for butt logs, saw logs and small-diameter logs. Thus, pulpwood was included only for processing value of the “corporate” buyer category using pulpwood by itself.

The performance of pricing mechanisms was tested with three different marketing scenarios. The first scenario depicted normal marketing conditions, where the demand for sawlogs at the time of harvesting is the same as it was at the time of buying the timber. The second scenario depicts a situation where the demand for long log lengths increases compared to short log lengths. The third scenario depicts a situation where the overall demand for sawlogs decreases and it is profitable to increase the minimum top diameter of saw logs.

Timber assortment recoveries, as well as the sale and processing values, are mainly dependent on the average stem size of the stand and the technical quality of the stems. To discover how the pricing mechanisms perform in different stands depending on the average stem size and quality data, stands were divided into subgroups (Table 7) based on the soil fertility and the average stem volume of the stand. The average dimensions in the subgroups are presented in table 8 and the average branchiness variables in table 9.

Table 7. Data classification according to site fertility groups and average stem volumes of study stands. OMT stands for site fertility of *Oxalis-Myrtillus* type, MT is for site fertility of *Myrtillus* type, VT is for site fertility of *Vaccinium* type and CT is for site fertility of *Calluna* type, according to Cajander (1926).

Subgroup	Site fertility	Average stem volume, m^3
Class 1	OMT, MT	< 0,60
Class 2	OMT, MT	0.60 – 0.75
Class 3	OMT, MT	> 0.75
Class 4	VT, CT	< 0.55
Class 5	VT, CT	> 0.55

Table 8. The number of stands, average diameters at breast height (dbh) and average heights by subgroups.

Subgroup	The number of stands	Average dbh, cm	Average height, m
Class 1	14	27.1	21.8
Class 2	11	29.8	23.4
Class 3	19	33.6	26.0
Class 4	9	25.4	19.9
Class 5	8	28.7	23.1

Table 9. Average branchiness variables by subgroups.

Subgroup	Average height of the lowest dead branch, m	Average height of the thickest dead branch, m	Average height of the thickest living branch, m	Lower limit of living crown, m
Class 1	5.0	9.7	16.1	13.8
Class 2	5.2	13.1	18.4	15.8
Class 3	7.7	13.3	19.1	16.4
Class 4	4.8	9.9	14.0	11.0
Class 5	6.1	12.2	17.5	15.0

4.2 Comparisons

4.2.1 Sale values

In the first scenario, where the demand for timber assortments and dimensions was the same at the time of harvesting as at the time of buying of timber, the sales values for different pricing mechanisms were scaled to the constant value of 100.00.

In the second scenario, where the demand for long log lengths was increased compared to short log lengths, all pricing mechanisms allowed the change of the price matrix to weight longer log lengths in the bucking. However, this change affects both the length-diameter distribution of logs as well as proportional timber assortment recoveries. Assortment pricing gave the lowest sale value for the forest owner for all buyer categories (figure 8). Price list pricing gave the second lowest sale values for all buyer categories. The smallest change in sale value was with the pricing mechanism of weighted timber assortment pricing. Pricing mechanisms of stem pricing and fractional stem pricing did not have any effect on the sale value since the sale value in these pricing mechanisms is not dependent on the bucking practised.

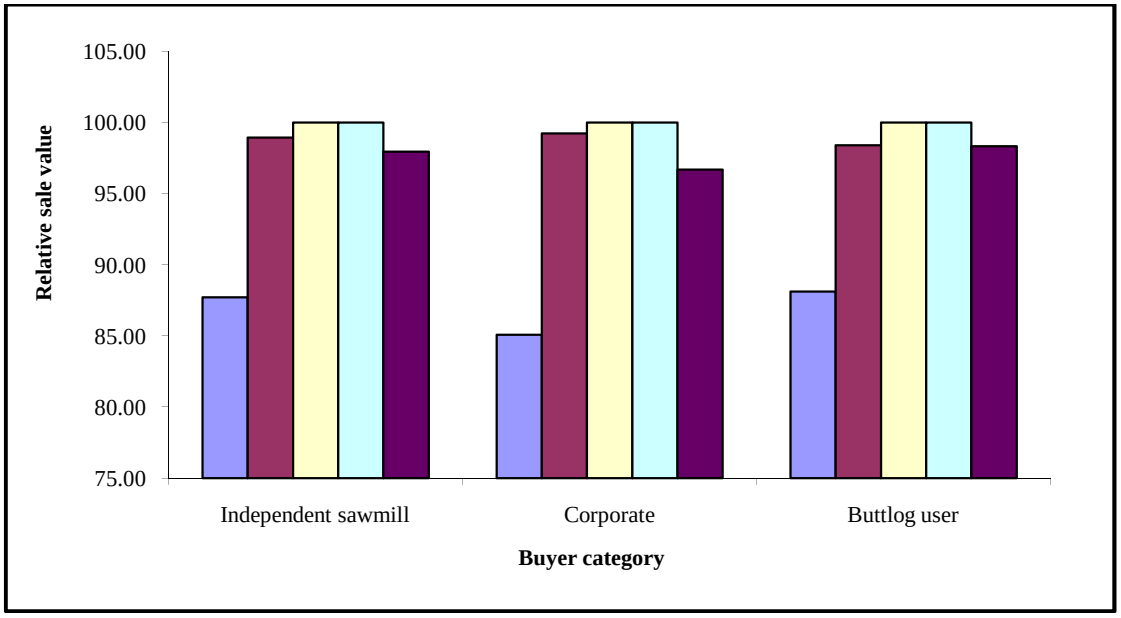


Figure 8. Relative sale values per cubic meter for buyer categories of independent sawmill, corporate and buttlog user in scenario two. The pricing mechanisms for each buyer category from left to right are assortment pricing, weighted assortment pricing, stem pricing, fractional stem pricing and price list pricing.

4.2.2 Co-variation of sale and processing value

The optimal pricing mechanism should offer incentives to grow high quality timber. In order to find out how the compared pricing mechanisms return added value achieved at the end use, the sale values were compared to processing values by correlation analysis (Table 10). The standwise correlations show that processing values correlate more with fractional stem pricing and price list pricing than with assortment pricing, weighted assortment pricing or stem pricing. However, the results concerning stem pricing are based on estimated timber assortment recoveries and therefore the correlations reflect the problems of assortment pricing.

Table 10. Correlations between the sale and processing values for different pricing mechanisms.

Pricing mechanism	Correlation
Assortment pricing	0.434
Weighted assortment pricing	0.493
Stem pricing	0.554
Fractional stem pricing	0.861
Price list pricing	0.751

According to the correlations between sale and processing values calculated by subgroups, the assortment pricing and weighted assortment pricing perform poorly when the average stem size is higher (Table 11). Fractional stem pricing performs better than price list pricing in the low fertile stands and fertile stands where the average size is higher. Price list pricing is the best in the fertile soils with the lower average stand volume.

Table 11. Correlations between sale and processing values for different pricing mechanisms by subgroup of stands.

Subgroup	Assortment pricing	Weighted assortment pricing	Stem pricing	Fractional stem pricing	Price list pricing
Class 1	0.539	0.506	0.524	0.452	0.669
Class 2	0.462	0.352	0.491	0.198	0.520
Class 3	0.351	0.315	0.035	0.680	0.502
Class 4	0.407	0.369	0.369	0.774	0.577
Class 5	-0.026	-0.131	0.673	0.849	0.447

4.3 Conclusion of analysis of pricing mechanisms

4.3.1 Value optimisation of raw material

From the tested pricing mechanisms, stem pricing and fractional stem pricing are the only methods which offer possibilities to optimise roundwood processing value in the bucking. However, in the case of independent sawmills or butt log users, pulpwood does not have value for the wood buyer. Instead, the bought pulpwood is often sold to the pulping industry for a price which hardly meets the costs. As a consequence of this, independent sawmills usually try to maximize the amount of sawable timber. They have to have a strong reason for not using sawable size timber themselves.

In the case of a corporation who owns saw mills and pulp mills, the balance between saw logs and pulpwood is flexible. There are times when there is a rationale for bucking excessive amounts of pulpwood even from sawable sized timber. Customer relationships are often considered very important and it may be better to keep the customer happy and produce lower value products if necessary rather than optimize the current value.

4.3.2 Incentives to grow high quality raw material

In general, the price of the product should reflect the demand of the product and the ability to pay. Since saw log value in production is dependent on the quality and dimension, the roundwood pricing mechanism should reflect the processing value of raw material on the forest owner's sale value. From the tested pricing mechanisms the fractional stem pricing had the strongest correlation between processing and sale values. The other pricing mechanism where the correlation between processing and sale value was strong was price list pricing.

The correlation was weaker with assortment pricing, weighted assortment pricing and stem pricing. However, the selected method of choosing stem price per stand was based on estimated assortment recovery and assortment pricing, thus the results are similar to assortment pricing. This does not have to be the method to decide the price in stem pricing, although in practice this has been the routine. Although it would be possible to set sale value and processing value corresponding, stem pricing does not give clear signal for forest owner to grow higher quality since there is no visible mechanism how stem quality actually affects the price.

Correlation analysis for different subgroups reveals that fractional stem pricing works better when the average stem size is higher and the fertility of soil is lower, and price list pricing works better when the stem size is lower and fertility higher. It can be assumed that, in general, higher fertility produces lower quality for Scots pine and therefore price list pricing gives protection against the reduction in the saw log recovery due to technical defects of the stem affecting bucking.

4.3.3 Transparency and understandability

The optimal pricing mechanism should be unrelated to the bucking practised, offering a predictable income for the forest owner and possibilities to optimize raw material value for the wood user. From the tested pricing mechanisms, stem pricing and fractional stem pricing are independent from the bucking. In order to maximize the forest owner revenue, three other pricing mechanisms, assortment pricing, weighted assortment pricing and price list pricing, require maximizing the volume of the most valuable assortments or log length-diameter distribution. Since the forest owner's net revenue is dependent on the bucking, the sale contract includes definitions of the type and dimensions of the timber assortments to be made.

In practice, modern harvesters use the bucking-to-value or bucking-to demand approach to steer the actual output of the length-diameter distribution of the logs towards the demanded distributions. However, both bucking methods diminish the value income for the forest owner (Piira et al. 2007). When using the price matrix where saw log lengths of 40-55 dm have values between 41 € and 49 €, the saw log recovery diminished from 76.2 % to 74.2 % and the sale value diminished 1.4 % compared to bucking where unit values of all the log lengths were 45 €.

In addition to the effect of price list on saw log and value recovery, the bucking-to-demand approach with near-optimal procedure has another way to diminish the saw log recovery and the forest owner's sale value. The harvester operator or the manager who compiles bucking instructions may define how much the optimal bucking of stem according to the log length-diameter demand may diverge from the maximum value of the stem. This percentage of allowed discrepancy is usually between 3 and 5 %. Bearing in mind also the possibility of the harvester operator affecting the bucking outcome, the differences between saw log recoveries of wood buyers may be notable. According to Rintala (2007), the average saw log recoveries of eleven wood buyers in Scots pine clear-cuttings (average stem size was between 400 and 500 litres) varied from 70 % to 80.5%.

According to the results of Berg's Master's thesis, assortment pricing is most vulnerable to changes in bucking objectives (Berg 2010). Price list pricing and weighted assortment pricing include the same risk, although price discriminancy of lighter and sturdier logs diminishes this problem. However, this problem leads to the need for third party control. For example, in Finland, where assortment pricing is the main pricing mechanism, approximately 75% of preliminary planning and control of timber sales is carried out by Forest Management Associations. The need for third party control leads to a net loss in the forest owner's sale value.

Figure 9. High quality Scots pine forest in Finland.

5 Recommendations for pricing mechanisms

5.1 Assortment pricing

Timber assortment pricing is a widely used pricing mechanism and statistics of roundwood trade are usually made using unit prices for saw logs and pulpwood. When using standing sales for clear-cuttings, the sell contract is made before harvesting, sometimes even years beforehand and agreed assortments, qualities and dimensions may not be valid at the time of harvesting. In the case of delivery sales the optimization of log length-diameter class distribution is difficult. Although the price for timber assortments varies according to the average stem size and quality, assortment pricing lacks transparent incentives to grow high quality timber. Despite the pricing method's straightforward principles, the forest owner's ability to compare different buying bids or estimate the actual value of the trade is limited, which leads to a demand for third party assistance (Hubbard & Abt, 1989, Larson & Hardie, 1989). In addition to this, conflicting interests in the bucking further complicate the confidence between the seller and the buyer, and further increase the need for third party assistance.

Timber assortment pricing has traditionally been used in many countries despite the clear shortcomings. It is recommendable to shift towards the pricing mechanisms which offer freedom to optimize raw material value, offer transparent incentives for the forest owner to grow high quality timber and which are transparent. However, during transformation assortment pricing should have a role as an alternative pricing mechanism for those who wish to use it. In addition to this, it should be reminded that these recommendations concern clear-cuttings and in thinnings assortment pricing has clear advantages.

5.2 Weighted assortment pricing

Weighted assortment pricing is very similar to conventional assortment pricing. The difference is that the most valuable assortment, saw logs, is divided into value classes. The advantage is that this offers incentives for the forest owner to grow sturdier stems with higher quality. Although weighted assortment pricing is a step forward from conventional assortment pricing, it has many shortcomings of assortment pricing and it is recommendable to use more efficient pricing mechanisms.

5.3 Stem pricing

Stem pricing offers freedom to cut stems as wanted and, thus, optimize the raw material according to the existing market demand. One price per unit volume or weight offers a clear vision of the value of raw material and the comparisons between different buying bids are easy to carry out if all buying bids are made using stem pricing. However, although it is assumed that the use of stem pricing would increase the price variation between low and high quality timber (Development of ... 2009), the incentive to grow high quality raw material is not transparent. Nevertheless, the advantages of stem pricing in standing sales are clear and the use of stem pricing would be mutually advantageous to both sellers and buyers. The advantages of stem pricing in delivered sales are not as visible, and stem pricing in these sales should be used with caution.

5.4 Fractional stem pricing

Fractional stem pricing is an extension of stem pricing where different size fractions of stem are priced separately. The disadvantage of this is that the actual price is more difficult to estimate, but the advantage is that fractional stem pricing offers clear incentives to grow larger sized timber. Although the use of fractional stem pricing requires harvester measurements, this pricing method is recommended for standing sales.

5.5 Price list pricing

Price list pricing is based on a price list, which defines the value for each log length, diameter and quality. Price list pricing has been used in Norway and Sweden, but for example in Sweden new pricing mechanisms have been developed because of the bucking-to-demand approach.

Price list pricing is a transparent pricing mechanism, although comparisons of price lists may be difficult, and on the other hand if the price lists are not specific to each individual mill, the use of price list pricing may lead to suboptimization of raw material. The use of price list pricing offers clear incentives to grow high quality timber.

Price list pricing has clear advantages when used in delivery sales. It gives the seller an indication of what kind of timber is valuable, and if the price list is correct the outcome of bucking should meet the needs of the buyer. However, in standing sales stem pricing and fractional stem pricing are simpler and give freedom to cut according to the market demand.

5.6 Development of pricing mechanisms

Pricing mechanisms based on expected processing value demand pre-information about raw material properties to be bought. In addition to the wood buyers' pre-information needs, forest owners demand similar information if the buying bids are made with different pricing mechanisms or if, for example, price lists used are not similar.

During the last 10 years, pre-harvest estimation methods based on sample measurements (e.g. Uusitalo 1995), non-parametric estimation and harvester collected databases (e.g. Malinen 2003) and air-borne laser scanning (e.g. Peuhkurinen et al. 2007) have been proven to produce quite accurate pre-information from marked stand. However, sample measurements are considered laborious, whereas air-borne laser scanning data is more suitable for large scale forest inventories than standwise pre-harvest estimation. Calculation methods might be cheap in use, but there is no commercial software available and if there was, the purchase price would restrict its usage.

In the EU's Northern Periphery Programmes project entitled "Developing the Scots Pine Resource" one of the aims has been to develop freely downloadable pre-harvest assessment software "Prehas" (Fig. 10) utilising non-parametric methodology and harvester collected databases (Malinen 2003). The computational methodology and easily collectable database ensures that this software will be usable anywhere where harvesting data collected by modern harvesters are utilised. The software offers a basis for development of new pricing methods based on more extensive knowledge of roundwood to be sold or bought. Prehas software has

three different versions; Prehas_Scotland for the Scottish environment, ARVO for the Finnish environment and Prehas_international for the rest of the boreal zone. Prehas software is downloadable from http://www.metla.fi/metinfo/arvo/index-en.htm.

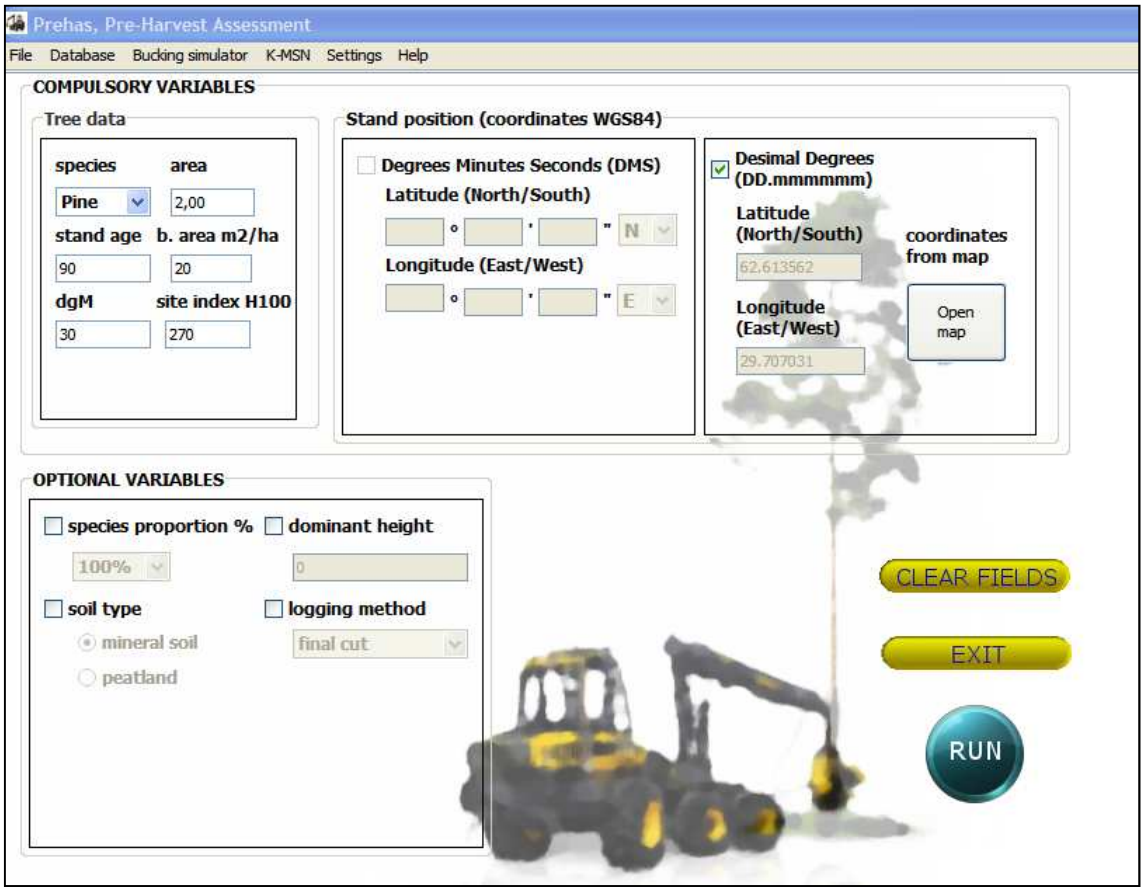


Figure 10. The user interface of Prehas software.

Nominal volume

The use of widely differing volume calculation algorithms is in a recent (FAO/UNECE 2010) report. In Europe, sawlog volume during trade might vary from over bark (Finland, Ireland) via a variety of solid wood estimates to small end cylinder volume (Sweden). For the partner in the log trade business, this might be quite confusing, in particular across borders.

One possibility to develop roundwood pricing is to use a so-called *nominal volume* (VN). In nominal volume, a nominal taper, typically 1 mm/dm from top to mid-way log length, is added to log top diameter (DT) to give a *nominal mid-diameter* (DM) (e.g. 2.5 cm will be added for a 50 dm long log). DM is converted to decimetre, and nominal volume VN in cubic decimetre is calculated by Huber's formula:

$$VN[dm^3] = \frac{\pi}{4} \times DM^2 \times L$$

Nominal volume is used in the Norwegian sawlog trade, in combination with certain specifications for rounding, deduction for bark in automated log scanners, length and diameter abatements, etc. (Grading and scaling regulations for coniferous sawlogs 1998).

Example. The log is observed to be 23.2 cm in diameter on bark and 467 cm in length. Bark deduction is 1.1 cm (by formula), so log diameter under bark is 22.1 cm. Then DT = 22.5 cm (median of class 22.0 to 22.9), and L = 46 dm (rounding down to nearest decimetre). Nominal taper to mid yields 2.3 cm, so DM = 24.8 cm or 2.48 dm. Finally, VN = 222 dm3.

The advantages of using nominal volume are (Gjerdrum 2009):

- logs with low taper (< 0.1 cm/dm) are allocated a higher nominal than actual volume, and vice versa;
- logs with low taper generally have fewer knots and represent higher quality, and such logs provide a higher price per actual volume;
- in primary breakdown, low sawn timber volume recovery results from high log taper (in particular for the main yield), and this is lower the longer the log is;
- during cross-cutting of the stem, high taper yields short sawlogs, in accordance with the sawmill's wishes;
- thus, this algorithm for nominal volume demonstrates coinciding economic incentives for the forest owner as well as for the sawmill.

In the development of the pricing mechanism the greatest challenges are the habits and attitudes of the parties in the value added chain of forestry. Through history, roundwood trade has developed in diverging directions in each country, and every partner will judge how any proposed change will affect their own interest. Wood buyers are under pressure to produce more and cut the costs down, which means that new habits which demand education and time are hard to implement. Forest owners are used to the current pricing mechanisms and the changes suggested from the buyer's side are often perceived as cheating. Moreover, third parties, usually forest owner associations, which negotiate on behalf of the forest owner and offer services for the timber trade for forest owners, are reluctant to give away their power or business possibilities.

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