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**of the Biennial Meeting of the**

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**Lom, Norway, 6th-9th April 2008**

**Even Bergseng, Grethe Delbeck,**

**Hans Fredrik Hoen (eds.)**

**Ås**

## SCANDINAVIAN SOCIETY OF FOREST ECONOMICS

### SSFE Board

Scandinavian Society of Forest Economics

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# Foreword

It’s a pleasure to present this volume containing papers based on presentations at the Biennial Meeting of the Scandinavian Society of Forest Economics (SSFE) April 6. – 9., 2008 in Lom, Norway. SSFE was founded by a group of young forest economists during the Nordic Forestry Congress in Stockholm in 1958. The Biennial Meeting in Lom was thus also a 50-year celebration of the foundation of SSFE.

On behalf of SSFE I thank our keynote speakers Senior researcher Stephanie Snyder, USDA Forest Service, Northern Research Station St. Paul and Senior advisor Audun Rosland, Norwegian Pollution Control Agency, for interesting and carefully prepared presentations.

The programme also consisted of an excursion with the theme *Nature based tourism*. I thank the organisers Sjur Baardsen and Ole Hofstad for preparing an interesting programme.

A memorable and tasteful 50th Anniversary Dinner was given on April 8th at the impressive place Vianvang, with the excellent cook Arne Brimi as host. For the first time in history SSFE appointed Honorary Fellows and the Board of SSFE had decided to give this distinction to three persons; Professors emeritus Asbjørn Svendsrud, Norway, Finn Helles, Denmark and Matti Palo, Finland. This was officially announced during the Anniversary dinner. A Diploma and a graphical print by Norwegian artist Jan Baker were given as physical evidence of the appointment.

The organisers and the participants wish to express their sincere gratitude to Samnordisk skogforskning (SNS) for indispensable financial support to the Biennial meeting. We also want to thank Grethe Delbeck and Even Bergseng for their efforts in planning the event and for help editing this volume.

Ås, December 2008

Hans Fredrik Hoen

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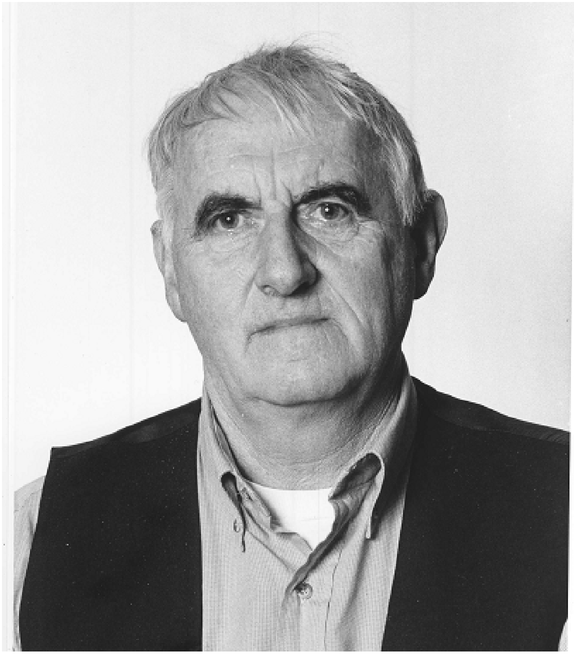

# Asbjørn Svendsrud

Asbjørn Svendsrud was born 14.07.1927. In 1954 he finished his master degree in Forestry from the Agricultural University of Norway (AUN), now Norwegian University of Life Sciences (UMB). In 1959 he got the degree Master of Science from the University of California, Berkeley. Svendsrud started as research assistant and research scholar at the Department of Forest Economics in 1954. In 1962 he was appointed assisting professor at the same department. Svendsrud was in 1964 appointed as associate professor and in 1978 full professor in forest economics.

Svendrud's professional work covers large parts of the field of forest economics and policy. Contributions regarding economic and profitability analyses regarding primary forest production is dominating, but also valuation of forest land for different purposes and more general resource economic questions are key parts of Svendsrud's production.

Svendsrud has over several decades taught forest economics and forest policy, as well as general resource economics.

Svendsrud served as Head of department at the Department of Forest Economics 1969 – 1990 (except for two election periods) and at Department of Forest Sciences 1993 – 1995. He has served as leader of the Forest Division at AUN and as member of AUN's Collegium, Study Committee and Research Committee. He was member of the Editorial Committee for Communications from Norwegian Forest Research Institute (NISK) for 30 years and also served as AUN's representative in the Board of NISK. He has been Norway's representative in IUFRO's International Council and in Samnordisk skogforskning. He has been member of the Scholarship Committee as well as the Advisory Board of Forest Research within the Agricultural Research Council of Norway. Svendsrud has been member of a number of committees and advisory boards and served as external examiner and evaluation committees for scientific position and degrees.

Svendsrud has published more than 150 scientific books, reports, articles, teaching notes et cetera.

Svendsrud has been active within SSFE ever since the first meeting which took place at AUN at Ås in 1961. Since then he has participated in most of the Biennial Meetings and served as leader of the organising committee for several of the meetings hosted by Norway. The first big cooperation project of SSFE was *Readings in Forest Economics*. The project resulted in a book that was published at Universitetsforlaget, Oslo, and Asbjørn Svendsrud was the project leader and editor of this book. It is fair to say that this was a successful project. After 40 years "*Readings*" provides relevant insight as well as an excellent overview of selected topical issues from the time of publication. Still in 2008, remarkably many of the chapters of the book address issues and challenges of high relevance.

**Selected publications Asbjørn Svendsrud:**


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Svendsrud, A. 1997. Skogbruk, grunnrente og skatt. *(Forestry, soil rent and taxation).* Meddr. Skogforsk 48:401-408.

Svendsrud, A. 2001. Tabeller for beregning av verdien av skogbestand. Rapport fra skogforskningen – Supplement 17. 16 pp + vedlegg 30 pp.

## Finn Helles

Finn Helles was born on the 1st of January in 1938. He obtained an MSc (Forestry) in 1963. In 1964 he took up a position as Assistant Professor in Forest Policy at the Royal Veterinary and Agricultural University, and in 1970 obtained his PhD-degree from that University within this field. He advanced to Associate Professor in 1972 covering the fields of Forest Policy and Forest Management Planning. He completed a Doctor of Science (Business Economics) with Copenhagen Business School in 1984, and was appointed Full Professor in 1985 with the Royal Veterinary and Agricultural University – now part of University of Copenhagen.

Finn Helles has always been travelling and searching for new inspiration. He has visitied numerous countries and has several times stayed for half a year as a visiting scholar abroad, e.g. at Reinbek in Germany (1967), at the university in Stockholm, Sweden (1971) and at Oxford, UK (1982).

Finn Helles' research interests are very broad, and reflect all the fields covered by his professorship: forest economics, forest policy and forest management planning. Furthermore, Finn Helles has a special interest in the role of forests for livelihood and economic development among the world's rural poor. Following a reform in the Danish research education system in 1992, Finn Helles saw the opportunity to enhance the research in the areas he covered. He steadily and skilfully recruited new PhD-students and expanded the research field. Today, almost 40 people work in these fields at Forest & Landscape, University of Copenhagen. His professorship has been replaced by no less than three new full professorships covering his area of work. Finn Helles has supervised more than 30 PhD-students himself, and to day more than 20 PhD-students work around him every day.

Finn Helles has published more than 400 scientific books, journal articles, reports, conference papers, lecture notes and popular articles on his work. He continues to be active as a quick search would reveal; see also the below list of selected works.

Finn Helles has been teaching several topics during his carrier, supervised almost 400 MSc-theses, and he has been and still is instrumental in the development of the Danish MSc in Forest and Nature Management. In particular, he has been a leading figure in establishing the ongoing international MSc's in the field at University of Copenhagen.

Finn Helles has served in several committees at the University over the years, was during a longer period member of the Danish Social Science Research Council, has been on the evaluation committee of numerous PhD defences around the world and not least has served for extensive periods on the board of SSFE, of which he has been a member for more than 40 years now.

Finn Helles is now Professor Emeritus at Forest & Landscape, University of Copenhagen. He continues to be in his office from 6 AM, to lead research projects, to travel, to write and publish, to supervise PhD-students and masters students, and to be influential in educational innovations and developments.

In short: Finn Helles continues to be indispensable.

**Selected publications of Finn Helles:**

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ANTHON, S., J. FRIIS LUND AND F. HELLES 2008: Targeting the poor: Taxation of marketed forest products in developing countries. *Journal of Forest Economics* 14: 197-224.

## Matti Palo

Matti Palo was born April 6, 1938 in Kokkola, Finland. He graduated as a forester in 1961 and passed his master degree some years later at the University of Helsinki. In 1969 he defended his dissertation on "Removal statistics based on a sample of buyers" and became a doctor of Agricultural and Forest Sciences at the same university. Thereafter he spent an academic year as a Post Doctoral Scholar at the University of California in Berkeley.

Matti's career at the Finnish Forest Research Institute Metla began in 1963, first as a junior researcher and later as a senior research specialist. He was working in 1976-79 as a Professor of Forest Economics at the Royal Veterinary and Agricultural University KVL in Copenhagen. He was nominated in 1985 as a Professor of Forest Economics at Metla. He held this office until his retirement in 2003. Then he was nominated as a visiting Professor of Environmental Policy at the Seoul National University in the Republic of Korea for 2003-2004.

Matti has also been working as an Adjunct Professor (dosentti) in Forest Economics at the University of Helsinki in 1973-2003. The University of Joensuu nominated him as Adjunct Professor in International Forest Policy in 1994. In 2001 he became invited as an Affiliated Professor at CATIE and later on as a Visiting Professor at the University of Peace in

Costa Rica. Presently he maintains a post of a Scientific Editor with Jussi Uusivuori of World Forests book series by Springer.

Matti has been internationally active throughout his career. He also encouraged and supported his colleagues to publish internationally and to participate international scientific meetings. During the 1970's and 1980's he worked as a consultant to FAO. After experiencing tropical deforestation particularly in the Philippines and Nigeria, he published his first paper on deforestation and its scenarios in 1984. He has rather regularly participated the meetings of the Scandinavian Society of Forest Economics (SSFE) since 1964. He was a member in the Board of SSFE in 1982-1984. Later on for more than ten years he chaired the Working Group on the studies of developing countries.

As his first major field of research, Matti developed national roundwood production statistics in the 1960's. Then in the early 1970's he focused on forest research policies. In the 1980's and early 1990's Matti moved to analyse national forest policies. His study on on the strategy of environment-oriented forest policy in 1993 had a strong impact on forest policy in Finland. In the mid 1990's he returned to research policy but at the international level. Matti also described in 1988 the unique evolution of forest-based development in Finland contrasting the deforestation in the Tropics. He is presently writing a book on this theme for Springer..

Matti has made research in a number of successive international teams. He has served as an External Project Leader for the European Forest Institute EFI and for the World Institute of Development Economic Research WIDER. In the mid 1990's he mobilized and led with Jussi Uusivuori a research program on "World Forests, Society and Environment", implemented in 1995-2001. This was a response to globalization of forest sector. The program was run from Metla with seven international research agencies and nearly 200 scientists from six continents.

Matti's scientific production totals more than 200 publications mostly in the fields of Finnish, international and global forest and environmental policy and tropical deforestation modeling, and a number of papers in conferences, seminars and workshops.

Behind Matti's energetic appearance have been life time interest in sports such as soccer, long distance skating on sea ice, cross-country skiing, bicycling and a love to his family farm house and home province of Keski-Pohjanmaa (in central western coast of Finland). The Kaustinen International Folk Music Festival traces back to Matti's newspaper article in 1965, an idea which he received from a folk music festival in Wales. In his home province he has also established and been chairing an NGO Alnus devoted to support forestry culture and history (www.alnus.fi).

Matti's passion has been to study and write polemic popular papers on Finnish forest policies, tropical deforestation and globalisation of forestry, forest industries and NGOs. He is still an active writer and discussion initiator on these issues. He holds an office as an external researcher at the Kannus Research Unit of Metla, next to his farm in his home province. Now and then he also finds time to sit down on his rocking chair, but only to collect new ideas.

Selected publications


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# What Contributes to a High Satisfaction of Report Publishers? An Approach with a Bayesian Belief Network

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## Abstract

The evidence of social and ecological responsibility has gained importance in the forest product industry. Sustainability Reporting could be seen an approach, which is able to capture effort and success of enterprises not only within financial dimension. New types of multidimensional reports have been developed in the last decade. However, little is known about reasons for the restrictive use of the new report types and it remains open if the new types are applicable in the forest products industries.

Therefore, in order to gain deeper knowledge in this respect a survey was conducted involving 400 forest products enterprises located in Germany, Switzerland and Austria. Special attention was given to attitudinal and behavioural questions. Furthermore, results were analyzed with a Bayesian Belief Network (BBN) which helped to detect the key components that can explain the various level of satisfaction with reporting.

As the results indicated, generally low satisfaction with the present reporting was concluded. Moreover, the BBN based sensitivity analysis provided evidence that (e.g.) a positive attitude towards new reporting standards and the publication of such new multidimensional reports increases the utility perceived significantly. On the other hand, strong negative influence was found for the publication of traditional report-types. Hence, BBN proved to be a feasible approach to explain the inner relationships and its explanatory power.

General recommendations for the future reporting in the forest product sector can be deduced.

**Keywords**: Reporting, Bayesian Belief Networks, Satisfaction with current reporting.

## Introduction

Compared with the situation of few decades ago, noteworthy increase of control of enterprises by society has been observed. Particularly the outcome of Rio Conference in 1992 forced enterprises to deal constructively with the issue of sustainability (Cahyandito, 2005). Attention of the public is given to the social and ecological performance of enterprises, rather than to the economical success. Therefore implementation of corporate responsibility (CR) strategies is of benefit to the enterprises (Loew et al., 2004).

However, it has not always been sufficient to implement such a strategy. According to a German saying *'act well, and talk about it'*, it is assumed that there exists a need to communicate efforts and success to the public. As a consequence, European commission recommended the implementation of new report-types (EU, 2001).

Consideration of new reporting schemes or the integration of non-financial content in traditional report-types are not really new. During the last decades many attempts were undertaken to integrate non-financial content into business reports. This lead to different types of reports such as social, environmental and sustainability reports. The various national and sector initiatives and reporting traditions produced unmanageable number of types, subtypes and individual reporting schemes, which lead to poor acceptance and lack of their comparability. In this respect the EU-commission indicated a need for the standardisation of contents, format and auditing of the individual report's quality (EU, 2001). Since 1999 the Global Reporting Initiative (GRI, 2002) developed an international reporting scheme for sustainability reporting. This approach has been increasingly accepted. Meanwhile more than 2500 reports using this standard were published worldwide. As far as concerned in the forest products sector this standard is up to now mainly confined to the industrial sector. Despite this fact few forest enterprises (producers of round-timber and forest contractors) have adopted sustainability reporting (e.g. ÖBF, 2005; Terranova, 2004; Coillte, 2003). The frequency in the wood processing industries is higher, however, still not to high.

Results of preliminary studies indicated that there is only little known on reporting in the forest products industries. In the context with an evaluation focussing on the present state of reporting and on the attitudes of the publishers towards some of these new approaches mentioned above (Hartebrodt and Wedel, 2006), the idea came across, to put these findings into a causal relationship.

The present paper contributes to the question, which the key-components are that can explain the satisfaction of the publishers in terms of the report-utility perceived. In this context we highlight the question as well, whether new multidimensional report types and concepts like standardisation of reports, participation and a higher transparency can be expected to improve the effectiveness of reporting.

The paper is structured as follows. In the first paragraph the brief introduction in the history of reporting in the forest sector is presented. In the second step the research gaps are outlined. The third paragraph contents description of the material and the theory of Bayesian Belief Network

(BBN). In later paragraphs the preliminary network, BBN based sensitivity analysis and results are presented. Conclusions are drawn and recommendations for future reporting activities are derived in the final paragraph.

## State of Reporting in Forest Industry

Reports play a substantial role in the communication strategies of enterprises. While a relevant number of enterprises issue reports, there is poor knowledge about the satisfaction of the publishers with their reports issued and the utility of this instrument.

For centuries the documentation of the volume harvested and sometimes the related revenues from timber selling dominated the reporting within the forest sector (Brandl, 1970). The years after World War II can be characterized as a period, where the statistical documentation of silvicultural activities and timber volumes has been prevalent (e.g. LFV 1955, RLP 1957). Reports of wood based industries reports have consisted mainly of balance sheets, based on national and mandatory accounting standards.

In the seventies some attempts have been undertaken to integrate, for instance, social aspects (LFV 1980, Kenk 1975). A new trend started after Rio-Conference and led to an increasing number of reports (in forest products industries), containing also ecological and again social aspects. In this respect it can be stated that Sustainability Reporting gained slowly but increasingly on importance.

New developments such as stakeholder participation, standardization of reports, approaches that lead to a higher transparency, are not very common down to the present day in the narrower forest sector and the wood-processing industries.

## Research Gaps

While the publication of reports requires considerable amount of time and money, it is astonishing that almost no relevant discussion on the present state of reporting and the satisfaction of the publishers exists. What is more, no evidence for a single publication on the effectiveness of this instrument in the forest and wood based sector in the German speaking region was found.

Present research in other trade lines focused on the quality (e.g. Loew et al., 2005) or perception of sustainability reports (e.g. PLEON, 2003). Generally speaking it has been argued in this study that new types of report are gaining importance, especially in larger enterprises, which adopt increasingly international reporting standards and thus mostly the standards of the Global Reporting Initiative (GRI, 2002, 2006). However this trend followed insofar traditional patterns, as the implementation is frequently done without any critical reflection on the strength, weakness, opportunity and threats related to the adoption of these new report types.

## Material

The survey was based on a structured questionnaire. Enterprises which were expected to have published reports were included. This sourcing was based on a literature and internet-study. The survey started on June 28th and finished on September 30th, 2005. The whole population amounted to 412. After nine weeks all enterprises received a reminder. We had 130 questionnaires completed (Table 1), which results into overall response rate of 32%.

**Table 1:** Sub-collectives, population and response-rates

| Sub-Collective | Public Forests | Private Forests | Contrac-tors | Sawmill Industry | Pulp and Paper Ind. | Sum |
|---|---|---|---|---|---|---|
| Germany | 26 | 34 | 10 | 73 | 52 | 195 |
| Austria | 13 | 18 | | 53 | 17 | 101 |
| Switzerland | 28 | 6 | | 63 | 19 | 116 |
| Population | 67 | 58 | 10 | 189 | 88 | 412 |
| Responses [N] | 43 | 25 | 12 | 16 | 34 | 130 |
| Response [%] | 64 | 43 | 120 | 8 | 39 | 32 |

The main focus of the survey was on demographic aspects of the individual enterprise, objectives and target groups of the present reporting. In addition, the appraisal of basic objectives and structures of sustainability reporting was assessed and the perception of different indicators based on an excerpt of the GRI-indicator set was questioned. We received frequency distributions with regard to the present reporting strategies (e.g. type of reporting, size of the enterprise). The perception of the multidimensional reporting approach and the GRI-indicators was tested using a four point (forced) Likert scale, with subject-related response scales. The detailed results were further reported in Hartebrodt and Wedel (2006, accepted) and Hartebrodt and Kenntner, (2008; accepted) [1].

## Methods

Bayesian Belief Networks (BBN, syn. Causal Probabilistic Networks, Bayes Nets) are statistical models, which are designed to visualize complex statistical structures of dependent items. The Bayesian Network originates in the Bayes theorem of so called dependent probabilities (Bayes, 1793). Each Bayesian network consists of a set of nodes and a set of directed edges between these nodes (see Fig. 1). Edges reflect cause-effect relations within the domain. The effects are normally not completely deterministic (e.g. disease → symptom). An important fact is that the strength of an effect is modelled as a probability (Jensen, 2007).

A great advantage of Bayesian networks is that the meaning of a node and its causal probability tables (CPT) can be subject of external discussion,

[1] In case of narrower interest, please contact the corresponding author.

regardless of their function in the network. The CPTs can be informed by several kind of information like expert knowledge, surveying results or empirical evidence. From the analytical point of view every item can be subject of prognostication or seen as influence factor.

*Example*

One of the most prominent examples is the so called ‘Apple Jack example’. ‘Apple Jack’ notices that his trees are loosing their leaves. He is aware of two potential reasons only: Drought and a (plant-) disease. This leads to the following BBN and its related CPTs and edges (Fig. 1).

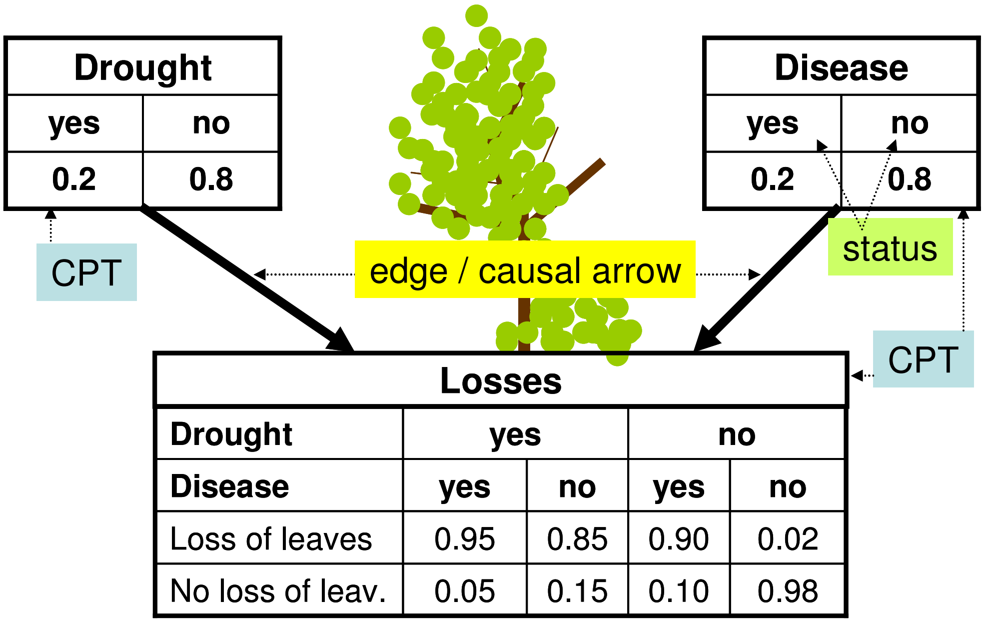


**Fig. 1:** The Apple Jack BBN-example

Drought and disease are so called parent (explaining) nodes to the dependent node ‘losses’. Each node requires causal probability tables (CPT). For the parent nodes only two probabilities for ‘yes’ and ‘no’ are required. The CPT for the depend node ‘Losses’ is rather more complex, as each potential case with its related probabilities needs to be specified. After the edges or ‘causal arrows’ are introduced, the nodes are linked and the BBN can be used for different kind of analysis. Subsequently, the sensitivity analysis was used. Example shows that the present state a total probability that the tree will basically loose his leaves is p = 0.305. This probability is called a priori probability. If the probability of drought or disease is changed to the extremes 0.0 (no/yes) and 1.0 (yes/no), the model is able to predict the related, so called a-posteriori probabilities (e.g. by watering or chemical measures) (Tab. 2).

**Table 2:** Sensitivity analysis of the 'Apple Jack Example'

| | Drought yes/no | Loss | Disease yes/no | Loss |
|---|---|---|---|---|
| | | [p] | | |
| Maximum likelihood | 1.0/0.0 | 0.870 | 1.0/0.0 | 0.830 |
| Present State | 0.2/0.8 | 0.305 | 0.2/0.8 | 0.305 |
| Minimum likelihood | 0.0/1.0 | 0.176 | 0.0/1.0 | 0.186 |
| Difference | 1.0 | 0.694 | 1.0 | 0.644 |

Table 2 above shows that the difference of losing the leaves between the maximum and minimum probability of drought is higher (0.694) compared with the difference of losses when the trees are diseased (0.644). Therefore evidence is given that watering would be more effective in order to reduce the risk of loss of the leaves.

## A Preliminary Network

We designed a preliminary BBN with the report utility perceived by the publishers as depended variable, as a strong indicator for the satisfaction of the enterprises issuing reports. The influence factors (parent nodes) can be clustered into three groups (see Fig. 2).

The first group of items contains factors, which are related to the new approaches in reporting. The overall attitude of such new 'reporting standards' is itself determined by the attitude towards transparency, participation in report-design and –process and the attitude towards multi-dimensional reporting concepts. The attitude towards multidimensionality is determined by the attitude towards different report contents in terms of economical, ecological and social information. All items are binary (positive or negative attitude).

As an influence of the target and actual readers is expected, the readership and the overlap between topical readership and target-readership as relevant influence factors are integrated. Figure 2 shows additionally five important stakeholder groups as potential readers, whereas the overlap between target and actual readership is binary coded.

The third cluster is formed by items, which characterize the present reporting and its framework. Included are present report types, the question, whether a report has been issued recently and the size of the enterprise as an important precondition that can be expected to take influence on the willingness and/or ability to publish reports. We had five relevant report types included in the underlying survey (business reports, balances, environmental reports, social reports and sustainability reports) and four groups for the size of the enterprise (in terms of the number of employees).

The utility perceived (as outcome or objective node) was ranked high, medium or low.

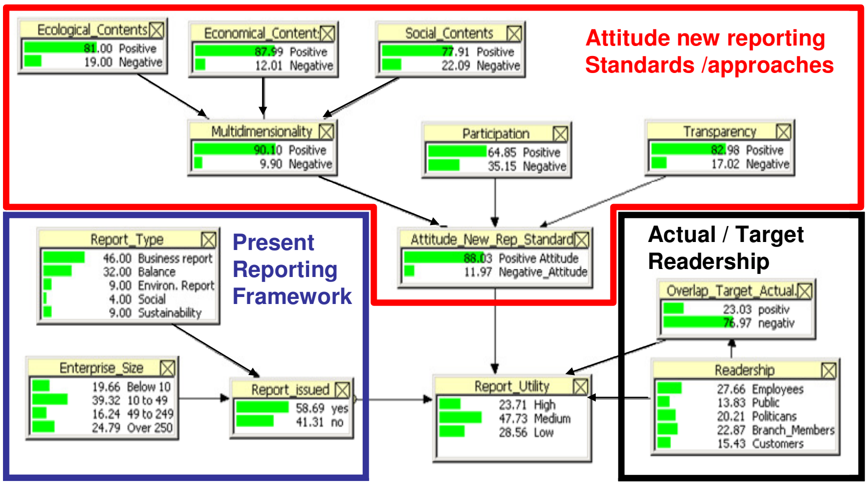

**Figure 2:** BBN Network for explaining the report utility perceived

## Results

The sensitivity analysis for each item and each status was undertaken. In this respect, 23 sensitivities from which 14 showed a positive difference with regard to the probability perceiving a high utility of reporting were identified. In nine cases a negative impact was found.

### Positive Impacts

Table 3 depicts the findings concerning items, which showed a positive influence on the satisfaction. The ranking with regard to the maximum absolute value of ‘high satisfaction’ and the sensitivity is very similar. However the item ‘attitude to new reporting standards’ and in some way the item ‘readership employees’ did not prove the same (see arrows in tables 3).

The difference (p = 0.106) in satisfaction between the interviewees who showed a positive attitude to the new standards and those who did not, was the highest with. This is not related to a high satisfaction of those who showed a positive attitude, but related to a rather low satisfaction of those who did not (p of high utility = 0.144)

It became evident, that all publishers who issued new and/or multidimensional report types (social, environmental, sustainability) had a higher probability to perceive a higher degree of satisfaction, among p = 0.090 and 0.073.

As relevant identified were found also the capability to address politicians and customers, a better overlap between actual and target readership, and a positive attitude towards participation in the reporting process.

Lower amounts in positive satisfaction showed the attitude towards multidimensionality and a high importance of employees as current report-readers.

**Table 3:** Items with a positive impact on satisfaction of reporting[2]

| Item | Absolute Ranking (by share 'high satisfaction') | Sensitivity Ranking (by difference max to min likelihood of each status) |
|---|---|---|
| Positive attitude new standards | | 0.106 |
| Report type: Social Report | 0.324 | 0.090 |
| Report type: Environmental | 0.307 | 0.077 |
| Report type: Sustainability Report | 0.304 | 0.073 |
| Readership: Politicians | 0.283 | 0.058 |
| Overlap target and actual Readers | 0.281 | 0.057 |
| Readership customers | 0.264 | 0.032 |
| Positive attitude new standards | 0.250 | |
| Positive attitude participation | 0.247 | 0.027 |
| Readership Employees | 0.245 | |
| Attitude multidimensionality | 0.239 | 0.014 |
| Readership Employees | | 0.013 |

**Neagtive Impacts**

Only weak distinctions between the ranking according to the sensitivity and to the absolute level of satisfaction were identified. 46% of the enterprises published traditional reports. Contrary to the expectations that could be derived from the frequency of the report type, this item showed the most relevant negative effect with regard to the modelled satisfaction and its difference. A highly negative influence of the public and the branch members as actual readers was found. Based on the findings, mainly enterprises with 50-249 employees showed difficulties with their reports (Table 4).

[2] Only Items with a sensitivity $p > 0.01$ are listed.

**Table 4:** Items with a negative impact on satisfaction reporting[3]

| Item | Absolute Ranking (by share 'high satisfaction') | Sensitivity Ranking (by difference max to min likelihood of item) |
|---|---|---|
| Report type: Business report | | -0.062 |
| Readership: Public | 0.190 | -0.055 |
| Readership: Branch Members | 0.197 | -0.052 |
| Report type: Business report | 0.204 | |
| Enterprise size 50 to 249 | 0.205 | -0.038 |

## Discussion and Conclusions

### Discussion

Current reporting activities in forest product industries follow traditional patterns of reporting. Only a small number of enterprises deals constructively with new approaches. However the results of the study provided evidence that this can't be the result of a high satisfaction with the present state. On the contrary it can be stated that a complete abdication of reporting would (theoretically) enhance the satisfaction with reporting notably. It could be concluded that the reporting is more driven by habituation than by conviction.

It could be observed that with increased use of traditional pattern in reporting the probability of low utility perception increases. Contrary to that the presented study identifies a coherent pattern that indicates that new approaches in reporting can be expected to enhance the satisfaction notably. A positive attitude towards new standards showed the highest sensitivity. The satisfaction of enterprises which issue such new reports (social, environmental and sustainability reports) showed the best absolute ranking in respect of their general satisfaction with reporting.

Remarkable is that the ability to address external readership-groups like politicians and customers were also relevant. However in the present state the reports are mainly read by members their institution. The results showed (Tab. 4) a low satisfaction when we are looking to the answers of interviewees who stated that this group is the most important one. Similarly a low overlap between the topical and the target readership explained additionally why there is a general problem with the accuracy of the present reports.

### Methodological Aspects

Generally application of BBN as a suitable approach to analyse data, which are mainly confined to attitudinal aspects could be confirmed. Sensitivity analysis allowed a very clear and rapid distinction between

[3] Only items with a sensitivity $p > 0.01$ are listed

factors, which determine the utility perceived notably and those which did not. The BBN was able to form a very coherent pattern to explain the key explaining components.

After we used these results as a base for a discussion with decision makers of a larger State forest enterprise, we agree with Smith et al. (2007) that these networks allow as well the involvement of stakeholder, or as done in the present case, of decision makers. The visualisation of the network facilitates the explanation of the results and enhanced the willingness of decision makers to adopt new approaches to a larger extent.

Some limitations arose, particularly the amount of data required and the (semi-) hierarchical structure of the network.

Despite the fact that we had 130 data sets available, it was only partially possible to inform the network completely. The more parent nodes and individual status were involved the higher was the risk of missing information in the nodes. A three-parent/three-status node leads to a $3^4 = 81$-field matrix. It occurred even in the case of a more ore less uniform frequency of the individual cases that parts of the matrix remain empty or weakly informed. These 'missing links' could have affected the sensitivity analysis notably.

In accordance with Smith (2007) it can also be stated that larger BBNs tend to dilute the influence of the individual factor. The closer a node is to the outcome or objective node, the stronger his influence is. When doing sensitivity analysis the position of the node in the network has to be kept in mind.

## Conclusions

Reporting in the forest product industry is presently only partially goal oriented. The reporting enterprises invest a large amount of time and money, but achieve rather poor effect. Therefore a traditional understanding of reporting can be challenged by the increasing demand of society of information on the ecological and social performance of the institutions and/or enterprises. Especially in the case of the forest enterprises it can be argued that there is a risk that the inventors of sustainability seem to avoid a critical review of these issues.

As it stands, one might ask question about where to start in revising of reports and/or reporting activities. In the present study it has been argued that there are a relevant number of hints that new approaches in reporting have the potential to improve the satisfaction notably. Despite the fact that only a limited number of enterprises have had experience with new types of reporting (e.g. social reporting, environmental reporting, sustainability reporting), the results showed that these standards can be expected to enhance notably the global satisfaction with reporting. Therefore it was not surprising that positive attitude towards the basic concepts of new report types (participation, multidimensionality, transparency) caused the same effect.

Communication theory underlines the need to identify the target readership and their specific information demand. Thus, the enterprises have to put more effort in the identification of their main stakeholder groups. A better overlap between topical and target readership could be another relevant factor to increase the satisfaction with the reports.

In summary it can be concluded that the knowledge about the information demand of the different stakeholder-groups is poor, or not existing. Therefore the identification of the perception of the various reports-types in different stakeholder groups and their attitudes towards the basic concepts of sustainability reports has to be analysed in order to meet the demand of a bi-directional communication between report-publishers and recipients.

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# A Hedonic Pricing Model for Hunting in Denmark

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## Abstract

This paper examines attributes that influence the price on hunting leases in Denmark. Landowners have the right to hunt on their land and the possibility to lease out this hunting right. The lease of hunting rights contributes to the landowners' income and in order to optimize total income it is essential to understand hunters' preferences for leasing an area for hunting.

The analysis utilizes detailed information obtained from 751 hunting contract leaseholders. The hedonic pricing method was used to find significant determinants that influence the market value of a hunting lease. Among other things we find positive influence from the bag rate of deer on the lease price, it is however relatively small. Furthermore, leasing out to consortiums rather than individuals seems to push the price upwards. Not surprisingly we find a significant reduction on the hunting price when the lease is between relatives.

**Keywords:** Hunting, hedonic pricing, recreation, natural resource management

## 1. Introduction

During the last decades the fluctuating, and mostly decreasing, timber prices have made forest owners aware of other sources of income from forest. One of these non-timber forest income possibilities is the revenue from leasing out land for hunting. In Denmark the hunting right belongs to the landowner and if the area is larger than 5 hectares, the landowner is allowed to transfer the hunting right for that specific area to a leaseholder or a consortium and thus be able to benefit financially from the wildlife resource. Management decisions aiming at maximizing net revenue of land is, however, often restricted by lack of information concerning what actually contributes to the value or the price of a hunting lease. An example could be large populations of deer that might result in crop damage due to deer browsing. Here it would be useful to know how much population sizes contribute to the price of a hunting lease in order to compare to the economic consequences of crop damage. Another example could be the importance of biotope improvement on the hunting prices. The cost as well as opportunity cost of land can then be compared to potential increase in hunting income. The economy of hunting is of considerable size. Thorsen and Strange (2000) report the total market value of hunting leases in Danish forests to presumably exceeding 13 million Euro per year. At present there is no study of the gross value of hunting in Denmark, but a recent Swedish study reports the gross value of hunting in Sweden to be around 335 million Euro per year (Mattsson et al., 2008).

Thus, the aim with the present study is to analyse this considerable market by identifying determinants of hunting prices in Denmark. We do that by asking hunters how much they pay for contracts and details about the area.

## 1.1 Literature

The economic value of hunting has been subject to a number of studies. Many studies operate within a stated preference framework using either contingent valuation (see e.g. Goodwin et al., 1993; Hussain et al., 2004; Fix et al., 2005, Mattsson 1989, Mattsson et al., 2008) or some kind of choice modelling (e.g. Boxall and McNab, 2000; Hunt et al., 2005). In the area of revealed preferences some studies using the travel cost method has been made (see e.g. Knoche & Lupe, 2006; Nguyen, 2007). Hedonic pricing is also frequently used (Livengood, 1983;Pope & Stoll, 1985; Messonnier & Luzar, 1990; Meilby et al.,2006; Zhang et al., 2006).

Common for all these studies, except Meilby et al. (2006), Mattsson (1989) and Mattsson et al. (2008), is that they are American or Canadian. Mattson (1989) and Mattsson et al. (2008) use CVM in Sweden. Meilby et al. is like the present study an examination of Danish hunting determinants. However, where Meilby et al. (2006) covered hunting leases at major Danish forest estates, the present study work with a larger, more widespread and probably more representative sample of Danish hunting leases. Furthermore, Meilby et al. collected data from estate owners, whereas we collect it from hunters.

Thus the study is novel in its empirical context of exploring an existing market for nature-based recreational goods. This is an important knowledge to gain, e.g. in order to optimise land management with multiple uses. In the following we will start describing the hedonic method used and the theory behind. Following the data collection and the results will be presented and we will finish by discussing the main findings. Some of the important results we find are that price per hectare increases by area and that the price increases considerably when a consortium is created.

## 2. Method

A hunting lease can be regarded as a composite good. Following Lancaster (1966) we will assume that a consumer derives utility from the attributes that goods possess rather than goods themselves. In this context it implies that hunters do not derive utility from the hunting contract *per se* but from the range of attributes or characteristics that are embodied in the hunting lease and the observed price

In economics, the hedonic demand theory (Rosen, 1974) is used to decompose values of composite goods into its attributes. It is often used to derive values of environmental goods or services that are not directly traded in the market by analysing prices of goods in related markets, e.g. houses who's price may reflect environmental attributes. Hunting rights are likewise traded on a market and we are able to apply the hedonic framework to identify attributes that significantly contribute to the price of a hunting lease. Among other things, the method assumes a large number of buyers and sellers, making the individual hunter as well as the land owner price takers.

Because of the large variation in hunting contracts, it is difficult to estimate the demand for generic hunting contract attributes. Following Lancaster (1966) we therefore assumed that a hunting lease can be reduced to its constituents parts and decomposed into attributes such as area size, land type, bag rate etc. We also assume that the market (the land owners and the lessees) value those constituent parts.

In this study, we develop a model to describe the price of hunting leases in line with other hedonic studies of hunting leases. The model consists of a number of vectors that are likely to affect the price of hunting leases. The first is a vector of predetermined characteristics of the area, which we call location variables. These include characteristics that the land owners are very unlikely to change. The second vector we denote area quality. This includes variables, which the owner to a certain degree will be able change such as the share of forest, the number of small biotopes etc. The third vector contains personal characteristics of the leaser/lessee, and finally a vector with variables that do not fall under any of the three above mentioned categories. The lease price per hectare *P* for a hunting contract, *i*, can thus formally be described as:

$$P_i = f(Location_i, Area_i, Personal_i, Other_i, \varepsilon_i) \qquad (1)$$

The model includes an error term $\varepsilon_i$, representing the effect of factors not observed and captured by the model. The specific attributes contained in the mentioned vectors can be seen in the first and last column of Table 1. From a landowner perspective especially the area vector is worthy of note because here he/she can affect lease price by management decisions.

An implicit price function is obtained by regressing the price of a hunting lease on attributes that are hypothesized to affect the price. To find the marginal implicit price (or willingness to pay) for one additional unit of a specific attribute, one needs to undertake the second stage of a hedonic price model. This implies taking partial derivatives of the implicit price function with respect to an attribute. In the present paper we do not undertake this second stage of the model.

## 3. Data

Members of the major Danish hunting organisation were in 2006/2007 through magazine articles invited to answer a questionnaire either at a specific site at the Internet or by requesting a postal questionnaire. The questionnaire was designed on the basis of discussions and interviews with hunters and tested in a focus group and elicited information regarding number of leases, attributes of the hunting area, price, terms of lease, etc. The respondents were also asked to state approximated game population and bag rates. Furthermore, questions about hunting preferences and socioeconomic characteristics were included.

A total of 1246 hunters answered the questionnaire. Because hunters were invited through articles and e-mails and not contacted directly we cannot calculate a response rate as such. Every respondent were compared to the hunting organisation's member register in order to ensure answers from hunters only and avoid doublets. This control removed 195 answers from the sample. A further 12 respondents had left blank answers at essential questions e.g. hunting price or area size and were thus also removed. Of the remaining 1039 respondents a total of 288 hunters were not holding a hunting lease and are therefore irrelevant for the following analysis.

## 4. Results

In Table 1 we present some descriptive statistics of the data. We see that the average area size for the 751 leases was 160 hectares and the average annual lease price per hectare was almost 300 DKK[4].

[4] 1 Euro is approx. 7.5 DKK. In the following DKK will be used.

**Table 1. Variable description. The prefix d_ indicates dummy variables.**

| Name | Min | Max | Median | Mean | Std error | Description |
|---|---|---|---|---|---|---|
| **Location Variables** | | | | | | |
| areasize | 5 | 2000 | 97 | 159.67 | 200.83 | Hectare per lease |
| price_hectare | 13.33 | 2000 | 239.69 | 298.75 | 236.81 | Price in DKK per hectare |
| ln_areasize | 1.61 | 7.60 | 4.57 | 4.57 | 1.01 | Log of area in hectares |
| ln_price_hectare | 2.59 | 7.60 | 5.48 | 5.39 | 0.84 | Log of price in DKK |
| west_x_reddeer | 0 | 8 | 0 | 0.11 | 0.71 | Bag rate of red deer crossed with region of western part of Denmark |
| D_Fyn | 0 | 1 | 0 | 0.10 | 0.30 | Region dummy |
| d_Sjaelland | 0 | 1 | 0 | 0.16 | 0.36 | Region dummy |
| d_nearcity | 0 | 1 | 0 | 0.13 | 0.34 | 1 indicates that the hunting area is close to a city |
| d_estatehunt | 0 | 1 | 0 | 0.29 | 0.45 | 1 if the lease is at an estate or similar |
| **Area quality Variables** | | | | | | |
| forest_share | 1 | 21 | 3 | 6.01 | 6.51 | Share of forest on the area in intervals of 5% |
| farmland_share | 1 | 21 | 13 | 11.21 | 6.73 | Share of farmland on the are in intervals of 5% |
| bagrate_deer | 0 | 70 | 4 | 7.50 | 9.39 | The bag rate of deer |
| activity | 0 | 300 | 30 | 34.13 | 26.34 | Number of hunting days for the lessee |
| d_oldforest | 0 | 1 | 0 | 0.26 | 0.44 | 1 if there is old forest present |
| d_cabin | 0 | 1 | 0 | 0.45 | 0.50 | 1 indicates the presence of a hunting cabin |
| biotope | 0 | 41 | 4 | 4.93 | 5.24 | The number of biotopes on the area |
| **Personal Variables** | | | | | | |
| Income | 0 | 10 | 5 | 5.22 | 1.63 | Income of hunter measured in 10 categories |
| d_careful | 0 | 1 | 0 | 0.01 | 0.12 | Indicating self reported carefulness |
| d_plus | 0 | 1 | 0 | 0.04 | 0.21 | Self reported issues that affect price upwards |
| d_minus | 0 | 1 | 0 | 0.07 | 0.25 | Self reported issues that affect price downwards |
| D_relative | 0 | 1 | 0 | 0.15 | 0.36 | 1 if the leaser and lessee is relatives, friends or similar |
| **Other Variables** | | | | | | |
| d_consortium | 0 | 1 | 1 | 0.82 | 0.38 | 1 if lessee is a consortium |
| contractlength | 1 | 99 | 1 | 3.30 | 4.54 | Length in years of the lease |
| d_contract | 0 | 1 | 0 | 0.31 | 0.46 | 1 indicates a formal contract compared to a verbal agreement |

Results of the estimations based on an ordinary least square regression are presented in Table 2. When developing a hedonic model there is no theoretical argument for choosing a specific functional form. Therefore we have been testing a range of different functional forms, including performing a Box-Cox specification test that yielded no guidance for the choice of functional form in relation to statistical properties. Based on statistical performance (highest r-square) we chose a log-log lease equation model where the dependent variable 'price per hectare' and the explanatory variable 'area size' are in natural logarithm.

**Table 2. Estimated coefficients for hedonic model of hunting lease price. Dependent variable is ln price per hectare.**

| Variable | Coefficient | Std. error | t-value | Pr > t | 95% Confidence interval | |
|---|---|---|---|---|---|---|
| Intercept | 5.912 | 0.151 | 39.20 | 0.00 | 5.604 | 6.187 |
| **Location Variables** | | | | | | |
| ln_areasize | -0.354 | 0.032 | -11.15 | 0.00 | -0.417 | -0.292 |
| d_Fyn | 0.423 | 0.073 | 5.78 | 0.00 | 0.280 | 0.568 |
| d_Sjaelland | 0.346 | 0.063 | 5.45 | 0.00 | 0.221 | 0.470 |
| d_estatehunt | 0.189 | 0.056 | 3.39 | 0.00 | 0.079 | 0.299 |
| d_nearcity | 0.143 | 0.064 | 2.24 | 0.03 | 0.018 | 0.270 |
| west_x_reddeer | 0.075 | 0.031 | 2.42 | 0.02 | 0.013 | 0.135 |
| **Area Quality Variables** | | | | | | |
| Forestshare | 0.010 | 0.005 | 1.91 | 0.05 | 0.000 | 0.020 |
| farmlandshare | -0.025 | 0.005 | -5.16 | 0.00 | -0.033 | -0.015 |
| d_oldforest | 0.141 | 0.049 | 2.88 | 0.00 | 0.045 | 0.237 |
| d_biotope | 0.007 | 0.005 | 1.61 | 0.10 | -0.001 | 0.016 |
| bagrate_deer | 0.020 | 0.003 | 6.21 | 0.00 | 0.014 | 0.027 |
| d_cabin | 0.365 | 0.052 | 7.08 | 0.00 | 0.264 | 0.467 |
| **Personal Variables** | | | | | | |
| Activity | 0.002 | 0.001 | 2.29 | 0.02 | 0.000 | 0.003 |
| d_relative | -0.285 | 0.062 | -4.58 | 0.00 | -0.406 | -0.161 |
| Income | 0.048 | 0.013 | 3.56 | 0.00 | 0.022 | 0.074 |
| Careful | -0.443 | 0.178 | -2.49 | 0.01 | -0.792 | -0.094 |
| d_plus | 0.303 | 0.104 | 2.92 | 0.00 | 0.099 | 0.507 |
| D_minus | -0.183 | 0.085 | -2.15 | 0.03 | -0.352 | -0.018 |
| **Other Variables** | | | | | | |
| contractlength | 0.012 | 0.005 | 2.43 | 0.02 | 0.002 | 0.021 |
| d_contract | 0.226 | 0.052 | 4.36 | 0.00 | 0.124 | 0.327 |
| d_consortium | 0.447 | 0.060 | 7.44 | 0.00 | 0.331 | 0.567 |
| N | 751 | | | | | |
| Adj R-Square | 0.5335 | | | | | |

Among several variables that were hypothesized to contribute to lease value we only included those with a significance level of 10 percent or better in the model. The variables with the greatest impact on hunting price will be described here.

Among attributes that contribute positively to the hunting price we see the region dummies for Sjaelland and Fyn. Furthermore, hunting areas leased to a consortium seem be priced some 45% higher than areas typically leased to individual hunters. Also, hunting leases based on a written contract compared to a verbal agreement seem to have on 20 per cent higher price per hectare. If a hunting area is equipped with hunting cabin, the lease price in the present sample will increase with almost 37 per cent.

Only a small number of the attributes investigated seem to negatively affect the price of a hunting lease (apart from the obvious negations, e.g. 'No cabin', 'No written contract'). First we see the negative coefficient of the variable ln_areasize, which suggests that the price per hectare is decreasing with increases in area size. If the landowner and the lessee are related there is a significantly reduction of the price at almost 30 per cent. In the end of the questionnaire we asked the respondents whether the hunting price was affected by something we did not cover in the questionnaire. A small part (see Table 1) replied that they were regarded as 'careful' hunters by the land owner, and they believed that for that reason they enjoyed a a sort of discount on the price. This discount is indeed found and is estimated to be around 45 per cent of the price. Further answers to the above mentioned questioned were categorized in price increases (plus) and decreases (minus) and shows the expected sign.

## 4. Discussion

First of all we see from the study that we have been able to explain about half of the observed variation by the chosen variables. And most of them behave as we would have expected. Compared to an earlier study (Meilby et al., 2006), the regional price difference is smaller. But it is not directly comparable as Meilby et al. only focused on forests. In the following we will start discussing the main findings and then briefly discuss the validity of the used method.

The analysis shows that a number of attributes affect the price of a hunting lease. Among these some of the location attributes contribute a great deal to the hunting lease. From a management point of view these attributes are not especially interesting as the owner is not able to easily change e.g. region or distance to a city. But obviously it is relevant for a hunting lessee, as he is able to travel. And it may be interesting e.g. in order to weight travel cost and hunting costs.

The bag rate of deer was found to positive influence the lease price which is in line with our prior expectation. However, the influence was estimated to be relatively small compared to some of the other area attributes, being 2% per deer in the bag (corresponding to some 8-10% for the median bag rate). The reason could be that hunters relatively easy can gain reasonable knowledge about location and area attributes such as forest share, distance to a city or the presence of a hunting cabin. However, they do not necessarily have any experience of hunting outcome in terms of bag rate. This is supported by the fact that the median hunting contract length is reported to be 1 year only. Some may renew the contract year after year, but it may indicate that some of the lessees perhaps had no experience or knowledge of potential bag rates at the time when they settled the terms of the lease including lease price. The number of biotopes at the hunting area also has a positive, but relatively small influence on the hunting price. We note that in our data, we only have access to information about the number of biotopes, not the size nor the quality. That two attributes, which in different ways are related to wildlife population do not contribute much to the hunting lease appears a bit surprising. One reason for this could maybe be found in the size of the hunting areas in the sample. The typical size (see Table 1) is around 97 hectares, which indicates that more landowners 'share' populations and thus the size of deer population is not only influenced by attributes on the hunting area examined but on neighbouring areas. In other words small hunting areas could lead to a sort of the classical 'Tragedy of the Commons' described by Hardin (1968).

We also se that consortium pays higher prices than individuals do. This may be due to the fact that consortiums are able to aggregate the willingness to pay for several hunters and hence outbid most individuals and secure the better hunting leases. It is straight forward that two or more hunters are able to pay more than one hunter. The fact that they seem also to be willing to pay more can either be because they pay for area qualities not covered by the other variables of the model, or because the land owner perceive the consortium to be a more costly lessee than an individual, e.g. the number of hunters present on hunting days may be much higher, and hence interference with other productions in the forest increase. Thus, it represents a supply side effect on the marginal cost of renting out the land. This also relates to the fact that there need not be rivalry between consortium members. E.g. if two members of the same consortium hunt on different days then the part of the utility related to the hunting or nature experience it self (and not the shooting) is not in conflict. Thus an argument could be that some part of the hunting lease is not a private good, but rather a club good (cf. nomenclature in Ostrom, 2003).

It is also worthy of note that the land owner's relatives or friends obtain discounts on the hunting lease. Interpreted combined with the observation that hunters who state they get a discount due to being careful hunters, e.g. shooting relatively few deer we argue that trust is a key issue: When landowners transfer their hunting rights and thus the management of the wildlife resource it is of great importance that it is transferred to somebody trustworthy.

Regarding the validity a few topics are worth noticing. It is often rumoured that the income from hunting leases are part of a black economy. Whether this is true or not is not to be determined in this paper. However, to avoid potential self selection in the sample we decided to ask the lessees rather than the leasers as the incentive to give truthful answers were thought to be higher from lessees. We could speculate of strategic answers from lessees as well, but it is ambiguous whether they would tend to over or under state their payment if they believed they by their answer could influence the market.

By only addressing members of the Danish hunting organisation we have not reached a representative sample of the Danish hunters. However, out of 163.600 active hunters in 2006/7 (Miljøministeriet, 2008) the 93.736 were organised in the Danish hunting organisation by the end of 2007 (Danmarks Jægerforbund, 2008), so a relatively large proportion is targeted. Furthermore, the focus has been on the price per hectare, i.e. area related. And even with a representative sample of hunters we would not necessarily get a representative sample of areas. Thus we believe that the form of collecting data have given a sufficiently good proxy of the average hunting price in Denmark.

## 5. Concluding remarks

In this study we analyse which and how much attributes of a hunting lease contribute to the price of a hunting lease. The results can be used in order to make informed management decisions that affect wildlife and hunting lease prices. We find that location specific variables determine the prices considerably, whereas the area quality variables have a smaller influence. Apparently also the relationship between the owner and the lessee is quite determining for the price setting.

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# Using lumber grade and by-products' yield predictions for standing scots pine trees in stand level optimization

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ABSTRACT

The purpose of this study was to develop models for estimating yields of lumber grades and by-products of individual Scots pine (*Pinus sylvestris L.*) stems using stem and crown dimensions as explanatory variables. The next stage will be combining models to simulation-optimization framework to optimize forest management at the stand level using climate change mitigation effect as an objective function when also material and energy substitution benefits of wood products are taken into account.

Two separate data sets were used as a material for analysis: 1) Simulated data set generated by the process-based growth model, PipeQual, which provides information about stem form and branch properties. The model was used to predict the 3D structure of Scots pine stems in thinning regimes of varying intensity and rotation periods and 2) detailed measured empirical data set. The stems were sawn using the WoodCim sawing simulator and the yields and grades of the individual sawn pieces, as well as by-products, were recorded. The sawn timber pieces were classified on A, B, C and D-grades for side and center boards separately (Finnish export rules). By-products were pulpwood, sawmill chips, sawdust and bark.

The response variables were formulated as proportions of the total volume of each stem. Multinomial logistic regression models were fitted to the both data sets. Models fitted to the real stems data set was found more accurate and the dead branch height, diameter at the breast height and the natural logarithm of the diameter at breast height was found the best combination of the explanatory variables. The models were tested in the generated data set and found to overestimate the quality in medium fertile stands.

The developed approach integrates forest management, its implications to the quality of raw wood and sawn wood conversion chain. The models can be used in stand management optimization for comparing different management options e.g. on the value-added basis from the sawmill's point of view or climatic benefits of wood products.

KEYWORDS: *Pinus sylvestris,* Timber products, product recovery, process based growth model, sawing simulations

# Conflicts between drinking water protection and income from Christmas tree production

Tove Enggrob Boon and Henrik Meilby

**Abstract**
Provision of pure drinking water is a main priority throughout Europe. At an overall level, The EU Water Framework Directive provides rules and guidelines for achieving a *good environmental status* in the water environment, including also drinking water resources. In Denmark, areas with valuable drinking water resources (groundwater) have been designated, so as to direct land use in these areas towards activities that enhance water protection. Forestry is considered a land use suitable for groundwater protection, and one of the aims of public afforestation is to protect ground water.

Forests cover 11 % (486,000 ha) of the land area in Denmark. The Forest Act allows production of Christmas trees and greenery on up to 10 % of areas designated as forest reserves (90 % of all forest areas).

Additionally, Christmas tree production takes place on farm fields. A total of 40,000 ha (8 % of the forest area) was forested with either Abies nordmanniana (ANR, Christmas trees) or Abies nobilis (ANO, greenery). However, the production of Christmas trees and greenery involves use of pesticides and fertilizers. This creates a potential conflict between the financial interests of the landowner and the common concern for groundwater protection.

The aim of this study is to investigate to what extent there is a geographical overlap between areas used for Christmas tree or greenery production and areas designated for groundwater protection, and how these areas are allocated to different types of owners (public, private). Implications for policy and practice are discussed. The analysis is based on data from a national forest inventory.

Key words: pesticides, ground water protection, greenery, Abies nordmanniana, Abies nobilis

# Cost–Benefit Analysis of Continuous Cover Forestry

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## Abstract

The several different versions of continuous cover forestry provide different portfolios of market and non-market effects. The extra harvesting costs of group or shelterwood felling are likely to exceed any savings in regeneration costs. Better financial returns come from successive removal of the largest trees by single tree selection. Continuous cover forestry will not necessarily reduce adverse effects of commercial forestry on water catchment, and may increase loss of water from the forest canopy: the economic effects are estimable from required costs of capacity replacement. Some additional value from carbon retention might be derived in single tree selection systems. Whether additional recreation or biodiversity values could generally be attributed to continuous cover forestry is doubtful. Landscape benefits are also questionable, though a pilot study concluded that about €60 per hectare per year might be attributed locally. Because of the delay between the costs associated with conversion to continuous cover forestry and the benefits of a converted forest, the rate of discount affects whether conversion would be deemed worthwhile.

**Key words**: cost–benefit analysis, continuous cover forestry, non-market benefits and costs, discounting

## Introduction

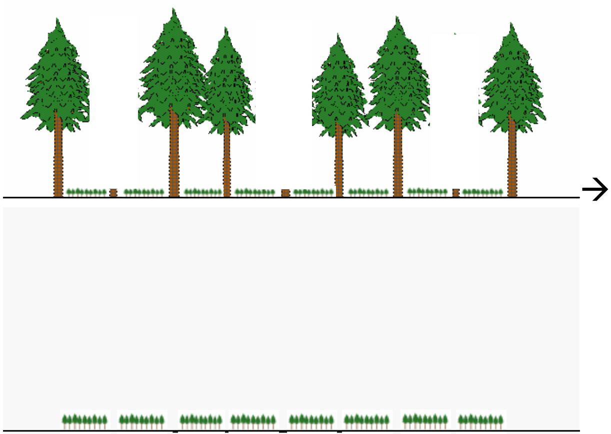
Continuous cover forestry has been (re)introduced to the UK on the basis of unsubstantiated allegation, and, in particular, of ignorance or misapprehension about its economic effects. Environmental considerations, not always well thought through, have propelled the change. In so far as there has been an economic input, it has been the perception that timber prices have fallen to the point where they cannot pay the costs of regeneration.

There has been much unnecessary confusion in the debate over what continuous cover forestry entails. "Continuous cover forestry" is not synonymous with low impact silvicultural systems nor with near-to-nature forestry – it can involve frequent and moderately heavy silvicultural intervention. It does not imply the use of mixtures, nor of native species only, nor exclusive dependence on natural regeneration, though all or any of those may be embodied in a particular application of continuous cover forestry. Continuous cover forestry implies, or ought to imply, continuity of forest cover: no less and no more.

Even continuity of cover does not seem to have been considered a strict requirement. In what follows, three broad versions of continuous cover forestry, as it has been discussed in the UK, will be distinguished, for the important reason that each has its own collection of costs and benefits, which may differ strongly between versions. A schematic presentation of each is given, as a backdrop to the ensuing discussion. There is difference of view about the precise specification of each version, but debate about nomenclature is not a principal purpose here. See Mason et al. (1999) for another account.

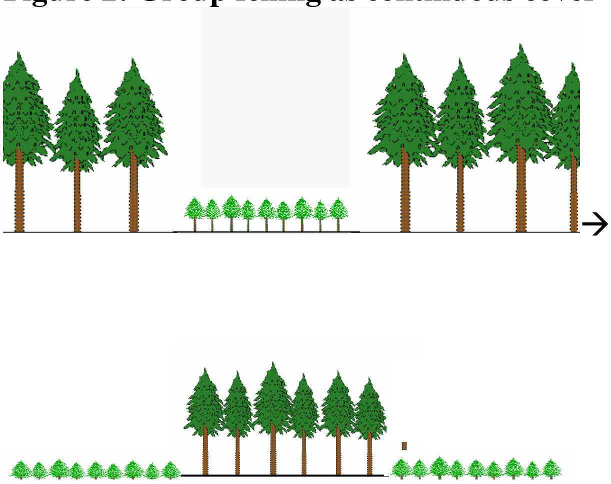
- Shelterwood systems involve establishment of a replacement crop, often but not necessarily by natural regeneration, before removal of a light canopy of the previous crop. A normal precursor is crown thinning to favour the trees expected to function as the shelter and the seed source for regeneration.

**Figure 1: Shelterwood as continuous cover**



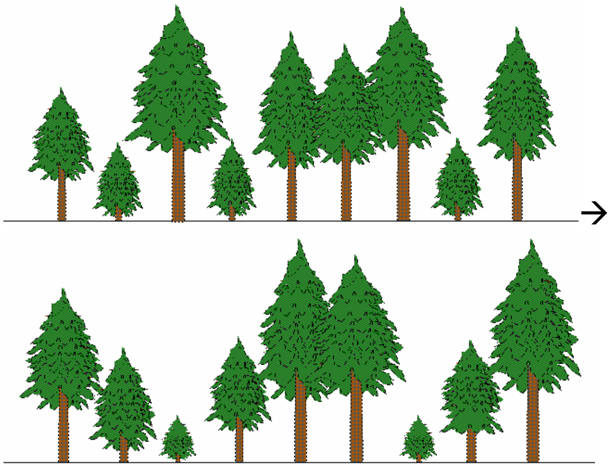
- Group felling entails cutting of small groups – variously sized between 0.1 and 0.25 ha in the normal UK interpretation, and possibly containing a few retained trees. The group is either extended successively, or further groups are formed until all the original crop has been removed. There has been some controversy about the size at which a group becomes "a small clear felling", and even about whether group cutting can be strictly termed continuous cover forestry at all.

**Figure 2: Group felling as continuous cover**



- Single tree selection entails removal of individual trees, classically of various sizes, on an on-going basis, so that there is no particular “regeneration phase”. The full range of age classes is maintained in the stand all the time.

**Figure 3: Single tree selection as continuous cover**



Within the version of continuous cover forestry depicted here there are also wide variations, from strictly controlled and implemented regimes, to opportunistic opening up of the canopy, when regeneration seems to be present and worth encouraging.

## Cost–benefit analysis

Cost–benefit analysis, understood broadly, is an economic appraisal of all the costs and all the benefits, whether marketed or not, to whomsoever accruing, both present and future, under a range of plausible scenarios, in so far as possible in a common unit of account, of alternative courses of action or allocations of resources.

There is again, it might be said, variety of interpretation between commentators, but the above definition contains all the main elements that might be present, and some would say that should be present, in a cost–benefit analysis.

There are also three modes of cost–benefit analysis. Financial cost–benefit analysis considers benefit as revenue, and cost as expenditure, for the agency responsible for a project or programme, and possibly also for other economic agents involved in its implementation. Economic cost–benefit analysis considers in addition benefits and costs which lie outside the market and accrue to all stakeholders, usually through the medium of *willingness* to pay. It also accepts that market prices are not necessarily an accurate reflection of opportunity costs of resources, and that environmental and social costs outside the market are appropriately measured as *willingness to accept compensation* for bearing them. Social cost–benefit analysis is a term much misunderstood at present. In its classical form, evolved in the 1960s and 1970s, its focus was not on products and resources, but on gains and losses to stakeholders. It was more often practised in the conditions of developing countries than in the UK. Those unfamiliar with the evolution of cost–benefit analysis often assume that social cost–benefit analysis means "cost–benefit analysis applied to social projects", but the distinctiveness lies in the approach, not the subject to which it is applied. The terms "environmental" and "extended" cost–benefit analysis are both redundant: cost–benefit analysis's scope in principle includes all costs and benefits anyway.

Within a classical decision-making structure –

1. setting objectives
2. defining alternatives
3. enumeration
4. valuation
5. synthesis
6. decision-taking
7. monitoring/*ex post* evaluation

– cost–benefit analysis concerns itself most with the stages of valuation and synthesis. Over the past few decades numerous techniques for evaluating non-market benefits and costs have formed the focus for efforts in developing cost–benefit analysis. There remains much disagreement on the relative merits and even validity of different techniques.

**Table 1: Methods of valuing non-market costs and benefits**

1 Marketable benefits are created or lost elsewhere in the economy as a result of externalities.
2 Financial costs are saved, imposed, or voluntarily undertaken elsewhere in the economy.
3 Comparable products are marketed elsewhere in the economy.
4 Voluntary subscriptions are made to related causes or campaigns.
5 Consumers/clients are asked what they would be willing to pay for a product, or what compensation they would accept for suffering a "bad" (this is the popular contingent valuation method).
6 Decision makers or experts ask themselves the same questions as in 5 above, or get a "feel" for acceptable answers.
7 The costs (including opportunity costs) of past decisions made to favour non-market benefits, or abate non-market costs, are taken as a measure of presumed benefit, or cost.
8 Willingness to pay for market goods which give access to non-market goods is measured.

Synthesis involves aggregating on the four dimensions implied in the definition: benefits and costs from different goods or for different resources, to different stakeholders, over different time periods, and across different scenarios. Great and ongoing debate attends each dimension of aggregation.

The following account is not about cost–benefit analysis of forestry, but about the *difference* between different types of forestry: the three versions of continuous cover forestry described, with clear felling or rotational forestry as the baseline, or "do-nothing", or "business-as-usual" alternative, against which the versions of continuous cover forestry are compared.

In the first instance, the annual benefits of each regime, once up-and-running, will be compared. This is tantamount to saying: "If a good fairy (Tait, 1987) were to offer you a choice among regimes, with a 'normal' distribution of age classes already established in each, which regime would you most like?" Of course, there is the further hotly-debated issue of whether it is worth transforming the existing regime to the ideal one, given the costs of the transformation *process* and the benefits of the transformed *state*. At the end of the paper the balancing of these matters will be addressed.

There is no attempt to present a particular and detailed cost–benefit analysis of an individual forest as it might be managed for either continuous cover forestry or for rotational forestry: such a study if properly conducted would be very time-consuming. Instead, relevant factors are raised and indicative figures are given for the kind of differences that might be found, with illustrations where appropriate from individual cases.

## Financial aspects

There is little empirical work which quantifies as much as the financial outlays and rewards that accrue to practising – even less to transforming to – continuous cover forestry in the UK. Sporadic forays into the field from continental Europe and North America have sometimes conflated the effects of continuous cover forestry with those of shortening rotations (Knoke and Plusczyk, 2001) or reducing the number of age classes (Kant, 1999).

By contrast, there are accounts suggesting that continuous cover forestry is a much more costly form of silviculture (Mäntyranta, 2007) which may in some circumstances be justified by environmental advantages, but should not be claimed as financially advantageous. This is certainly the perception of many private foresters in the UK.

Experimental work at Trallwm Forest in Mid-Wales has investigated in detail the harvesting costs that may be involved in transformation (Price, M., 2007). Three conventional harvesting treatments were included: continued low thinning directed towards a later clear felling; group felling, in which low thinning was practised in the matrix outside the groups and a few large trees were retained within the groups; a "frame tree" treatment which used crown thinning to favour large wind-firm trees that would form the basis of a shelterwood. A fourth thinning treatment was designed from an economic perspective, with the following indications in mind.

- Early revenue is better than delayed revenue.
- Big trees make more money per cubic metre than medium-sized trees.
- Very fast-grown trees yield poor quality timber.
- Taking small trees in thinnings increases investment.
- Felling before or after optimal rotation incurs a cost.
- Trees may not survive past a critical height.
- Large canopy gaps encourage regeneration.
- The more trees are planted, the more it costs.
- Prolongation of transformation is a bad thing, if the target system offers higher profit.

Fuller discussion is given in Price and Price (2006). These considerations lead to a thinning regime which, from about halfway through the rotation, takes the largest diameter trees remaining in the crop, leaving increment to be put onto remaining, smaller trees. A similar regime has been advocated from the point of view of silviculture and utilisation of timber, though with a somewhat different rationale (Sterba and Zingg, 2001).

**Plate I: Harvester operator's view of economic thinning [photograph: Martin Price]**

In addition, a "premature clear fell" treatment was used, as an alternative to continuous cover forestry in order to raise early revenue – an advantage sometimes claimed for continuous cover forestry. In the event the site was of such high productivity that the stand was already close to its optimal rotation. This treatment thus afforded results relevant to timely clear felling at the end of an economic rotation.

Some costings from this work suggest the following, against a base-line of clear felling costs. It must be borne in mind that up to 50% of volume with rotational forestry might be removed by low thinnings. But the same would be true for much of the rotation for group and shelterwood treatments, but less so for the economic thinning treatment.

**Table 2: Cost of harvesting per $m^3$ for the experimental treatments**

| Treatment | Clear cutting | Low thinning | Group felling | Shelter-wood | Creaming |
|---|---|---|---|---|---|
| Cost/$m^3$ | £9.72 | £13.00 | £12.79 (£11.80) | £11.42 | £9.95 |
| Difference from clear cutting | – | £3.28 | £3.07 (£2.08) | £1.70 | £0.23 |

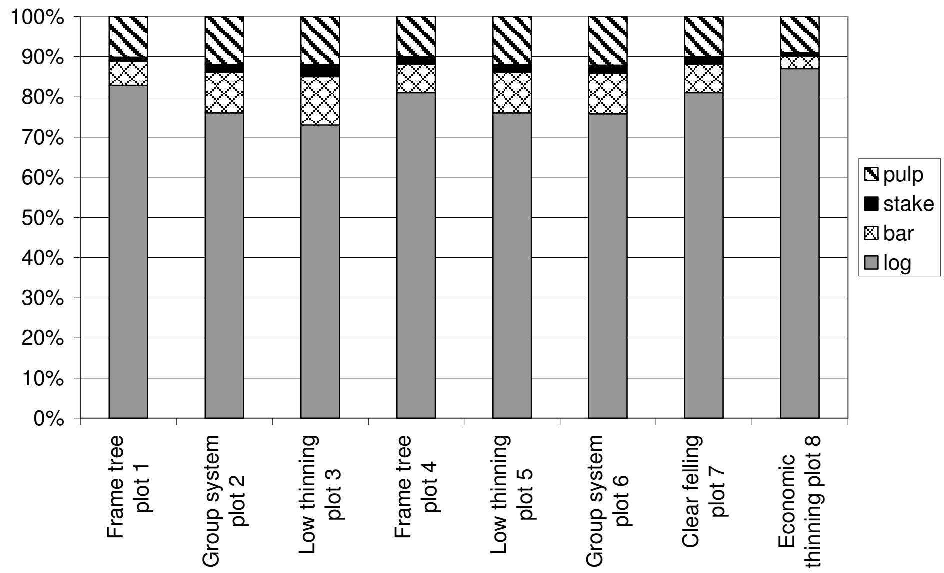
Figures in parentheses are estimates. The original group felling cost included the (high) cost for low thinning the area surrounding the groups. Separate figures for groups and surrounds have not yet been calculated.

Bearing in mind that the chief financial advantage of shelterwood and group treatments is hoped-for avoidance of regeneration costs (saving of an amount generally less than £1000 per hectare), and with clear felling volumes of around 400 $m^3$ per hectare on this site, the harvesting penalties are quite likely to exceed savings.

Moreover, deviation from optimal rotation (small trees being felled before optimal rotation, or large trees being felled after optimal rotation, or both) by definition reduces profitability.

The economic thinning treatment, by contrast, might not incur any net harvesting penalty, once up-and-running, because it is always large trees that are harvested. Even in the short term it has a much smaller penalty than any other treatment, except premature clear felling. Moreover, the product assortment, even during transformation, appears to be highly advantageous, greater proportions of volume being produced in the highest value product categories than by any other treatment, including clear felling (see figure 4). This condition is likely to be perpetuated once a single tree selection system is up and running, provided that it is managed with the object of concentrating increment onto final crop trees.

**Figure 4: Comparison of assortments by percentage of volume produced**




Felling times may well be at about the optimal rotation for individual trees, even during the transformation period, as the trees felled are the ones furthest advanced towards the ideal product assortment, and achieving the lowest indicating percent (value of increment divided by sale value of tree).

Early indications are that regeneration is, at the least, not worse under the economic thinning than under other treatments. However, natural regeneration of Sitka spruce in Wales is notoriously unpredictable: one cannot assume that this result, if maintained, will be reproduced on other sites.

The main concern is with potential dysgenic effects of early removal of the largest tree sizes. At feasible levels, these are sufficient to outweigh the cost and price advantages of economic thinning as a mode of transformation to continuous cover forestry. The concern arises during the transformation period. Beyond that, the large trees removed are large because they are the *oldest*, not the *most vigorous* of the crop. There would be a case for attempting artificial regeneration experimentally, to get through this phase.

Questions have been raised about implications of economic thinning for biofuel production, as a shift takes place towards larger product assortments. Brash baling as a source of biofuel cannot be undertaken without due regard to possible nutrient and hydrological effects (Anon., 2007). Consideration of carbon emissions does not necessarily favour small dimension biofuel material over large dimension structural material. Barrow et al. (1986) demonstrate that the greater saving in fossil fuel per unit forest production may in fact be achieved by substituting renewable structural materials for non-renewable ones

The economic models developed in conjunction with the Trallwm project are capable of including an increased value for small dimensions in the assortments shown in figure 4: sensitivity analysis can be conducted readily.

## Hydrological effects

In the wet northern and western parts of the UK where commercial conifer forests are concentrated, experimental results have indicated a significant net loss of water run-off following conifer afforestation (Calder and Newson, 1979), though the strength of the effect is not agreed even among hydrologists. Commercial afforestation has also been considered responsible for increased sediment loads and acidity of water supplied (Edwards et al., 1990). On the positive side, forest rooting systems encourage rapid infiltration of intense rainfall, and hence may mitigate flooding. In recent times in the UK, catastrophic flooding has become frequent, with a perceived increase in frequency of extreme climatic events. Costs attributed to individual flood events may run into thousands of millions of pounds. This is not to say, however, that forests, even on entire catchments, would have avoided such costs. Calder (2007) suggests that alleviation of flooding by forests will not avoid the most extreme events.

However, Robinson (1998) has speculated that the impacts of continuous cover forestry might be rather different, in particular in less concentrated ground disturbance, leading to more diffuse physical and chemical effects on watercourses.

The expectation would be of little differential effect on water infiltration and hence on flooding and low flows, between continuous cover forestry and rotational forestry.

There might be more reason to suppose that there would be differential effects on sediment loads, owing to the more dispersed nature of harvesting under continuous cover forestry. This would apply to small headwater catchments (on the scale of individual forest sub-compartments). However, for forest scale catchments, the profile of harvesting activity through time would be similar under either regime, whether as diffuse activity through the entire area, or intensive clear felling of a small proportion of area, and diffuse thinning activity in much of the rest. If, as some claim, continuous cover forestry produces a greater total yield than rotational forestry, that would be cause to expect greater site disturbance, but this claim is not generally agreed. It has been argued that continuous cover forestry produces insufficiency of brash to allow an adequate protective mat for the soil surface. However, Price, M. (2007) shows that in all the transformation treatments studied, there was a fairly similar and generally adequate mat. No research was encountered to substantiate or refute the view that sites left open by clear felling are vulnerable to additional disturbance by direct impact of rainfall. Indeed, the dripping of amalgamated water drops from a tree canopy may have a more erosive power than the fall of a finer rain, and hence lead to greater sediment loss. Only a multi-storeyed canopy suffices to mitigate such an effect, and it is not offered throughout a growth cycle by any of the continuous cover forestry forms discussed above.

**Plate II: Ground disturbance happens under continuous cover forestry too**

Pricing of any differential effect can be addressed by considering the cost of the downstream consequences of sediment loads, as effects on fisheries, requirements for dredging, and in particular need to treat drinking water supply. In one celebrated extreme rainfall event, an area of recent afforestation led to costs amounting to £4000 per hectare afforested (Stretton, 1984). This catastrophe was not repeated everywhere: it has become notorious precisely because of its unusual severity. It would be a gross error to take this cost as a base-line, against which the benefits of any modified form of management should be compared. The area involved represented only 0.1% of the area afforested in Wales in the twentieth century, and foresters are quick to point out that the policy for water is more aware of and sensitive to potential problems these days (Forestry Commission, 2003). Moreover, as discussed above, the differentials between continuous cover forestry and rotational forestry are likely to be small for forest-scale catchments.

Evaporative loss from the canopy would be expected to differ between types of cover. As Robinson (1998) observes, in rotational forestry the canopy does not close until several years into a rotation, and in the phase where the ground is relatively bare of both trees and grass or shrubby vegetation, evaporative loss may be less than for a grassland or forest cover. By contrast, continuous cover forestry has no phase when there is no tree cover, so might be expected to cause continuous evaporative loss, compared with a grassland baseline. Moreover, the roughness of a multi-storeyed canopy increases the evaporative potential related to turbulent air-flow over the canopy, and potentially its greater canopy volume could intercept more rainfall to be the subject of evaporative loss. No experiments on the hydrological effect of continuous cover forestry in the UK seem to have been initiated, but indications of additional loss might be derived, speculatively, from the observed increase of evaporative loss per unit area in small woodlands (Roberts and Rosier, 2006); from hedgerows (Herbst et al., 2006); and from line-thinned forests (Calder, 1990), all of which present more aerodynamic roughness and greater edge-to-area ratio. Approaches to pricing this loss are discussed below.

**Plate III: Evaporative loss from continuous cover forest, Glen Tress**

**Pricing water loss from forests as lost benefits**

There are two problems with costing the impact by this method.

- Domestic water supply is at present mostly not delivered at a price per 1000 litres, from which lost benefits could be evaluated. (Industrial use *is* priced, however, or the impact of reduced supply on industrial output could be calculated.)

- Except in very dry years the loss may be of no significance, because existing capacity more-than-suffices for needs.

Hence an appropriate approach might be to translate the greater speculated losses of water as a result of continuous cover forestry, into the greater costs of maintaining a reliable supply in the face of these losses.

**Pricing water loss from forests as the cost of advancing investment**

This technique is due to Collet (1970). A more recent application appears in a study of costs and benefits of forestry in England's South-West Region (Land Use Consultants, 2002). The first variant looks at an annual cost of maintaining the additional capacity required as a result of additional evaporative losses. The second is based, like the Collet approach, on the cost of bringing forward new investment. From either perspective, the cost to water resource agencies of afforestation is substantial, comparable, say, to the financial cost of establishing a hectare of conifer forest.

**Table 3: Costing water losses through forestry – South-West Region**

| | |
|---|---|
| Extra reduction in rainfall run-off when canopy closed | 15% |
| % of rotation during which loss occurs | × 50% |
| Mean annual rainfall (mm) | × 1400 |
| Thousand litres/ha/mm rainfall | × 10 |
| Cost of new capacity / 1000 litres / year | × £3 |
| | = £3150 |
| Annual cost equivalent of this | |
| Interest rate | × 6% |
| Cost per ha **per year** | = £189 |
| **OR** | |
| If time lapse until new capacity is required is 25 years, | |
| discounting @ 6% | £3150÷ $1.06^{25}$ |
| Cost per ha **in perpetuity** | = £734 |

Note that this cost assumes that rotational forestry involves full canopy closure only 50% of the time. For genuine continuous canopy, the losses might be doubled. Hence the figures quoted above would *also* be the cost of water loss through continuous cover forestry. This does not allow for any additional evaporation due to turbulence or edge effects.

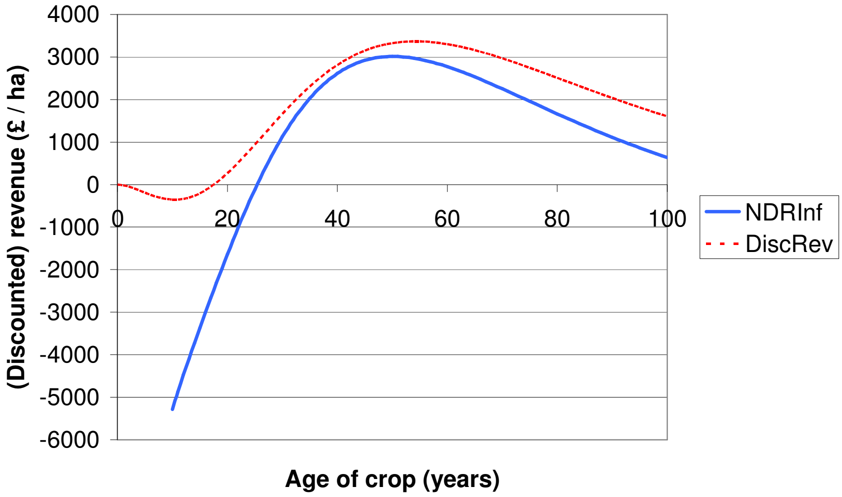
Of course, this is not a pervasive cost against forests. Conventional reservoir catchments occupy only 1% of England and Wales's land surface, though a much higher proportion lies upstream of water intakes. There are clear implications for land use policy concerning the mutual location of continuous cover forests and utilised water catchments.

Further illustrative costings of potential water losses could be derived from Barrow et al. (1986), who investigated the effect of forestry on hydroelectricity generation, but assuming that only the first 12 years of a 50 year rotation would be free of extra evaporative losses. Again, differential losses from continuous cover forestry could be of the order of hundreds of pounds per hectare, depending sensitively on local meteorological factors and particularly on the joint operating head of all hydroelectric power schemes being fed from a point on a catchment.

## Carbon storage and climate change

Claims have been made that rotational forestry has no advantage in relation to carbon fixing, because all carbon fixed is released to the atmosphere at the end of the rotation period. By contrast, it is said that continuous cover forestry maintains carbon stocks indefinitely. This view represents a misunderstanding of rotational forestry, in which all stages of a rotation are likely to be present, in roughly equal proportions, at any scale above that of the individual tree stand. The relevant scale in relation to global climate change is global, and clear felling occurring anywhere on the Earth's surface should be compensated by growth of rotational forests occurring elsewhere. Broadly speaking, there is no differential benefit between rotational forests and continuous cover forestry of the group felling type. Shelterwood continuous cover might store more carbon on average owing to the retention of the overstorey beyond a normal economic optimal rotation. But a similar increase could be obtained by prolonging slightly the rotation of rotational forestry, which has little effect on profitability, as shown in figure 5. A lesser financial sacrifice is required by such brief prolongation for the whole final crop, than for a proportionately longer prolongation for part of the crop.

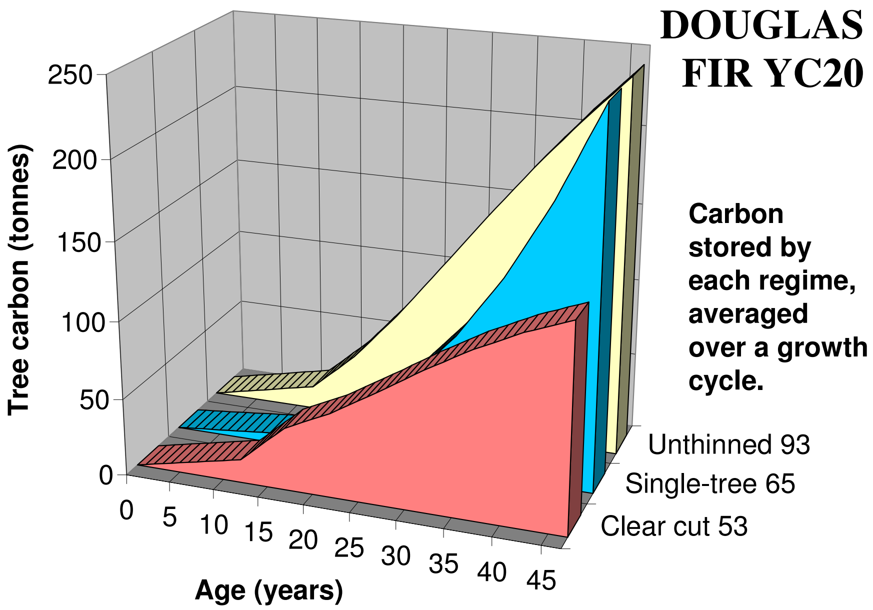
**Figure 5: The minimal effect of slight prolongation of rotation with rotational forestry**




Other strategies than changing to a continuous cover forestry regime are more effective to increase forestry's carbon storage benefits: for example, not thinning, or fertilising low-productivity crops (Hoen and Solberg, 1994).

By contrast, single-tree selection in which thinning is done *only* by means of removing full-sized trees does offer some benefits compared with a conventional thin-and-clear-fell rotation. The figure below shows an example of the profile, and average, of carbon storage for a single tree selection regime managed to give constant diameter increment of trees through their lives.

**Figure 6: Carbon storage under various regimes**




There may be further advantages from soil carbon storage, but no information, even speculative, was found on this effect.

A wide range of figures for the price of a tonne of carbon in the form of carbon dioxide may be found in the literature, from £0 to £240 in a survey by Price and Willis (1993). Newell and Pizer (2001) more recently quoted figures in the range £5–10 only. The Department of Trade and Industry however suggests £70 per tonne. This is a value for a flux of carbon, rather than for a state of storage, an important distinction because the relationship between such concepts depends on discount rate. The £70 figure could be applied to the result of switching state from rotational forestry to continuous cover, say over 20 years. The consequent value would be less than £1000 per hectare, and rather speculative in any event. An annual equivalent for the value of "keeping carbon locked up" would be up to £30 per hectare.

## Recreation

Three effects of continuous cover forestry are relevant to recreation.

1. The effect on visual experience of recreationists. This is treated under the landscape heading.
2. Accessibility into the stands.
3. Screening the presence of other recreationists, and hence reduction of the sense of crowding.

Many evaluations of forest recreation using the travel cost method (Clawson, 1959) have been made over the years (e.g. Christensen et al., 1985; Benson and Willis, 1992). None gives any insight into the value of converting to continuous cover forestry.

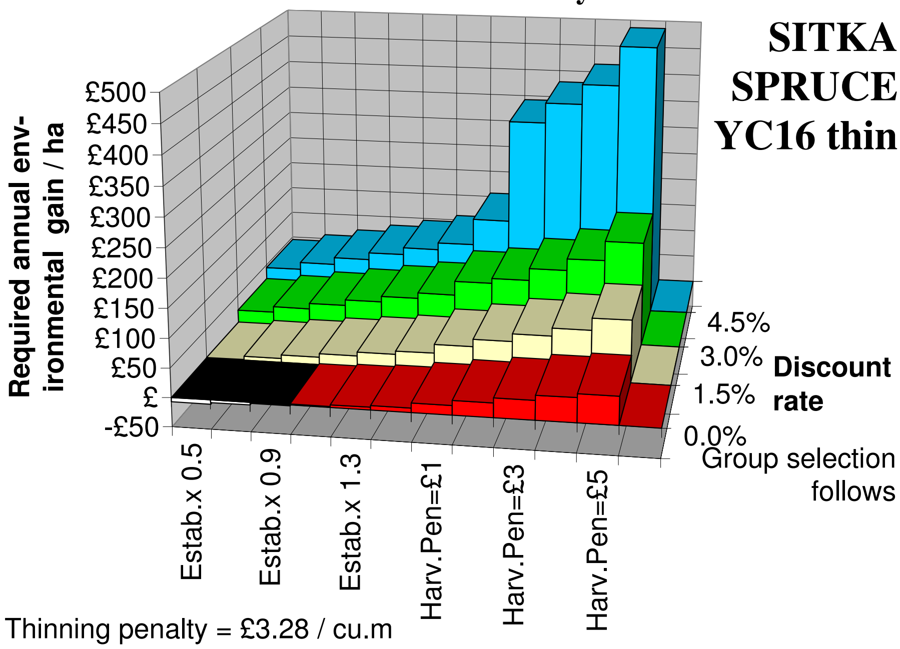
Chambers and Price (1986, also Price, 2004) found that the influence of forest type on understorey vegetation had a strong effect on the density of *visible* visitors, and suggested that this might be one reason why perception of and dissatisfaction with crowding have not been strongly correlated with actual numbers of visitors on site. The monetised value of freedom from crowding has only been quantified speculatively (Price, 1979). It depends sensitively on the type of environment and the crowd-aversion of the visitor.

Only single tree selection would definitively give more effective and pervasive screening than rotational forestry, which itself provides – and has been claimed by foresters to provide – effective screening. This would be a relevant consideration when it is deemed desirable to screen particular facilities which may compromise the sense of naturalness, such as mountain biking trails.

Accessibility constrictions may counter-balance the screening benefits of single-tree selection: some respondents to a landscape questionnaire explicitly mentioned possible difficulties of access into the denser continuous cover forestry stands. Accessibility under continuous cover forestry may be further compromised by the greater proportion of time when harvesting work is being undertaken in a particular small area. The percentage of time actually active is unlikely to be great, but more frequent disturbance of trails may bring greater re-routing and reinstatement costs. We know of no costing of such effects.

It can be said that the less economically attractive forms of transformation to continuous cover forestry require a surprisingly high level of compensating environmental benefit, up to hundreds of pounds per year with unfavourable assumptions, as shown in figure 7. Such levels of benefit may readily be forthcoming in the environs of popular tourist accesses, but are unlikely to be achieved in the majority of commercial forest areas, which remain little visited by recreationists.

**Figure 7: Illustrative environmental gain required to offset cost of transformation to continuous cover forestry**



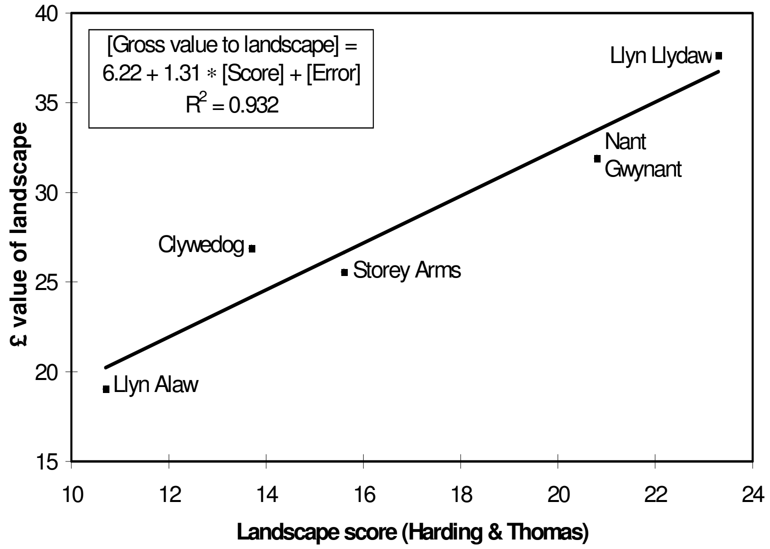

## Landscape

In a survey (Price, C., 2007b) of public preference between continuous cover forestry and rotational forestry, responses suggested preferences: for "naturalness", as embodied in continuous cover; and for views, as embodied in rotational forestry; and aversion to felling, as embodied in both. The more widespread preference for continuous cover forestry generally speaking persisted even when presented as a sequence of views, in which rotational forestry showed greater variation *between* views.

As to monetisation, Hanley and Ruffell (1993) provide a contingent evaluation of variety. But this work did not identify the effect of variety *between* views, only that *within* them, and so gives no basis for comparing the different scales of variation offered by continuous cover forestry and rotational forestry.

A very different basis for valuation is provided by relationships between subjectively assessed aesthetic quality, on a well-established and tested scale of 0–30, and willingness to pay to travel to different types of landscape (Bergin and Price, 1994; Price and Thomas, 2001). The correlation, based on travel costs for car-borne parties averaging three persons per car, is far from perfect, but it provides a rough-and-ready basis for valuing improvement to landscape, 44p per person per day being attributed to a one-point advance up the landscape quality scale.

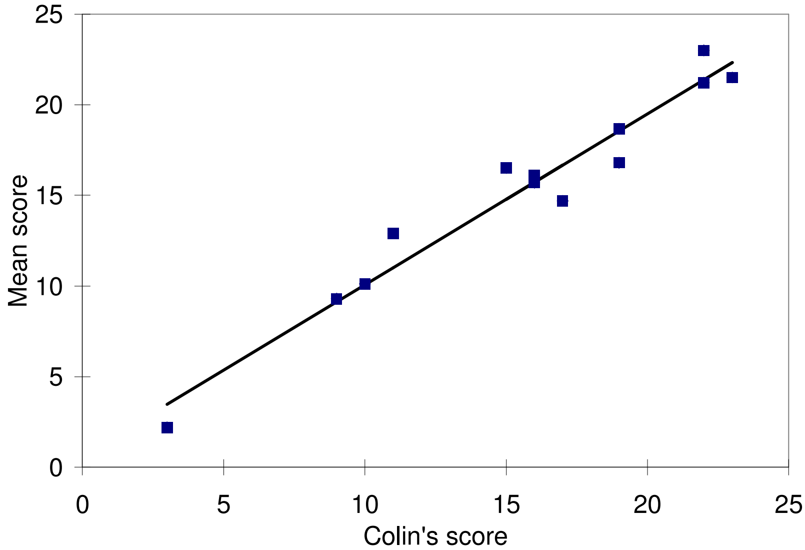
**Figure 8: Landscape quality and willingness to pay**




To translate the quality of different landscapes into cash values requires mapping from the scale used in the landscape project mentioned above, to the 0–30 Harding and Thomas scale (a variant on Fines's 1968 scale) used for the work quoted above.

In general, the correlation between subjective Harding and Thomas scores, even for untrained evaluators, is remarkably good, despite the perception that "subjective" implies "unsystematic". In particular, evaluators calibrated to the preferences of groups may be able to estimate mean scores remarkably well, as shown in figure 9, *for landscapes of different quality*.

**Figure 9: Relationship of subjective scores**




Such does not seem to be the case for valuation of landscape *types*, as evidenced in a my own personal preference for the portfolio of experiences offered by rotational forestry in the landscape preferences questionnaire.

Given this different slant of preferences, it is not possible to map from scores on the 0–10 scale as expressed in the questionnaire, to scores on the 0–30 Harding and Thomas scale, as assigned by myself and quite at odds with those emerging from averages of the landscape questionnaire. As an expedient, scores on the two scales were sorted by rising magnitude and related, giving scope to compare ranges and sensitivities. The slope coefficient was 3.5, indicating that each point rise on the 0–10 scale translated into 3.5 points rise in the 0–30 scale. There was nothing to suggest that the relationship was other than linear. The mean score for the continuous cover forestry photographic set was 1.2 points higher than for the rotational forestry set. The illustrative value of preference for continuous cover forestry rather than rotational forestry was thus as given in table 4.

**Table 4: Mapping landscape scores to landscape values**

| | |
|---|---|
| Additional landscape points for continuous cover forestry | 1.2 |
| Coefficient to convert to Harding and Thomas scale | × 3.5 |
| Value per point per day | × £0.44 |
| Scale up for change in retail price index from 1994 to 2007 | / 83.8 × 104.6 |
| Aesthetic value for continuous cover forestry on a day's visit | = £2.31 |
| Number of forest visits per year (Anon., 2004) | × 200,000,000 |
| Hectares of forest | ÷ 2,840,000 |
| "Days" per visit (Anon., 2004) (hours/visit:hours/active-day) | × 0.25 |
| Value per hectare per year | = £41 |

Considering the number of speculative steps, this might be regarded as a quite reasonable figure. It accords in magnitude with the willingness to pay for all the services of "natural" woodland evinced in voluntary subscriptions to the Woodland Trust (Price, C., 2007a).

It is, of course, a mean, and would vary by several orders of magnitudes between least and most visited forest sites.

If I am less confident about this result than for any other landscape valuation I have ever made, it is not only because my own judgements seem – unusually – to be at variance with those of a wider population. There are clearly several more or less tenuous steps in converting scales. It is by no means certain that the photographic set gave a representation of the experience of a forest walk. And the value is probably applicable in any case only to those parts of forest visits deliberately chosen as such: those which just happen in passing by might have a different evaluation.

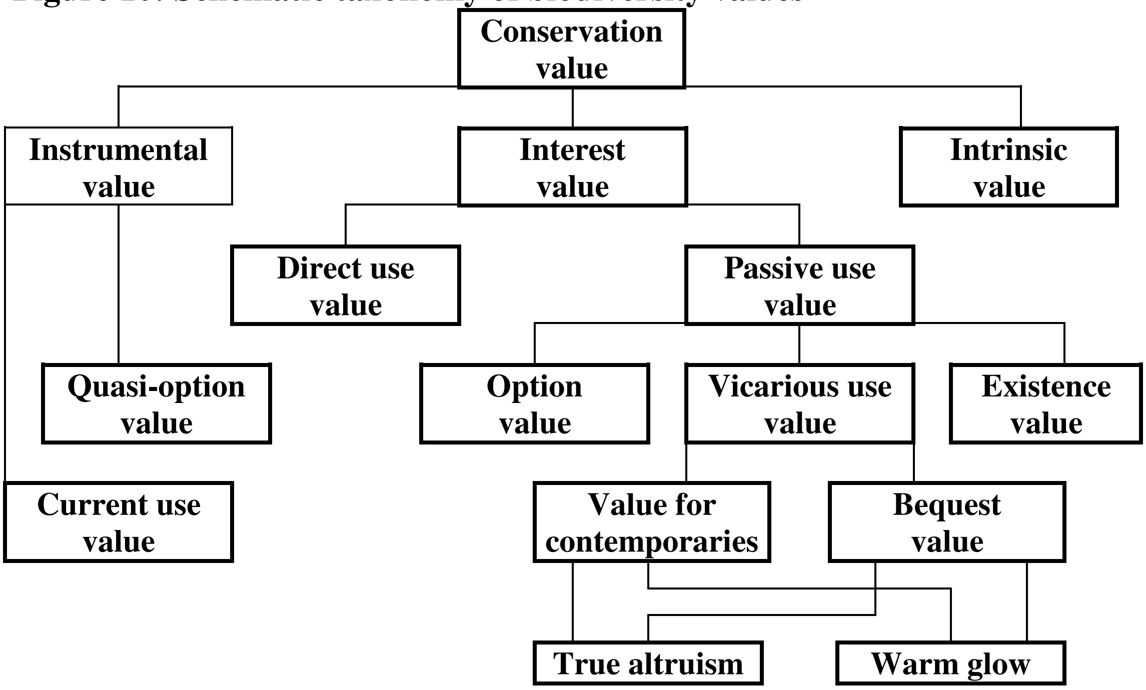
## Biodiversity and ecosystem functions

Whether continuous cover forestry is good for biodiversity conservation depends not a little on what is being conserved. How valuable that effect is, depends on what it is being conserved *for*. Some species are celebrated for being favoured by clear felling and even-aged replanting: nightjars (*Caprimulgus europaeus*) and short-eared owls (*Asio flammeus*), for instance. The medium scale interspersal of age-classes seems particularly to suit roe deer (*Capreolus capreolus*), to the extent that they are regarded as, at the least, a nuisance by most UK foresters. On the other hand, for species such as red squirrels (*Sciurus vulgaris*) which proceed through the canopy rather than along the ground, the intimate mixture of age classes represented by single tree selection provides an amenable environment.

There may be a perception that continuous cover forestry is almost near-to-nature forestry, but the fact is that it entails about 10-12 harvesting interventions per growth cycle, whereas unthinned rotational forestry may entail only one, thus favouring species for which undisturbed forest habitat is the main requirement.

Very like agroforestry, some forms of continuous cover forestry provide an abundance of edge habitat. Whether this is in general a prime and rare habitat in a landscape of greatly fragmented patches is debatable (Price, 1995). Then there is the question of the purpose of conservation.

**Figure 10: Schematic taxonomy of biodiversity values**




The three major categories of conservation value shown in figure 10 may be distinguished as below.

- **Instrumental value** comprises contributions to material well-being that could acceptably be provided by other means. For example, net photosynthesis by forests reduces atmospheric $CO_2$; but as far as global climate is concerned the reduction could just as well be achieved by reduced use of fossil fuels.
- **Interest value** is the source of pleasure to people which *habitats or species themselves* provide. This rather superficial-sounding term is also intended to embrace deeply felt cultural and spiritual values attributed to sites and species.
- **Intrinsic value** is whatever good is held to subsist in *the very being* of the habitats or species, independent of any human experience or knowledge of them.

Current use value might be approximated by Costanza et al. (1997)'s celebrated, though controversial estimate of ecosystem service values, amounting to thousands of pounds per hectare. However, this is a very coarse figure, and cannot be related to the relatively subtle differences between continuous cover forestry and rotational forestry. Such services are best valued, as has been done above for water and carbon dioxide, on a highly individual basis.

Within UK forestry at present the sourcing of berries and mushrooms does not assume the importance that it has in parts of continental Europe. (Saastamoinen (1997) quotes a value of around FIM 335 million for Finland in 1995, the equivalent of around £55 million in today's £ values, or only about £2.50 per hectare of Finnish forest, with a similar value for hunting.) The Countryside and Rights of Way Act of 2000, making it illegal to sell collected produce, unintentionally obstructs derivation of a market value. It seems unlikely that such values will constitute a very general case for continuous cover forestry.

On "PAWS" sites (plantations on ancient woodland sites), management which is closer to natural light regimes is more likely to be favourable to retention of unknown genes that are embraced in quasi-option value. Simpson et al. (1996) have suggested that such quasi-option values may not have the $1000 per hectare figure sometimes claimed for tropical moist forests, but may be as low as 20 cents per hectare. Caution should therefore be applied to using top-of-the-range figures derived from the more enthusiastic literature.

Direct use interest values are encompassed in recreation value, of which approximately 35% was attributed to "viewing wildlife" by Benson and Willis (1992).

It is easy enough to derive by contingent valuation an impressive passive use value for the conservation of almost any species or habitat type presented in interview, even up to tens of thousands of pounds per hectare. Such values are often, arguably, symbolic, representing a wish to identify positively with the conservation cause (Price, 2001).

To achieve a believable value for *one form of habitat rather than another* is a much more difficult task, and is likely to prove the more difficult, when the habitats are rather similar. It may be helpful to specify the categories into which conservation values may be divided, as in figure 10. A good rule of thumb derived from experience, would be to use a zero difference of value, rather than the extravagant figures which habitually emerge from contingent valuations.

Intrinsic values are deeply misunderstood by both economists and conservationists. (A rational account is given in Stenmark (2002).) These values arguably have nothing to do with rarity, and everything to do with biomass of sentient organisms, and from this point of view there may be little to choose between continuous cover forestry and rotational forestry: the sentient biomass just comes in differently shaped or coloured or textured packages. The biggest misconception is that it makes any sense to attempt to apply a cash quantification to these values. This is a step beyond the frontier at which cost–benefit analysis makes quantitative sense (Price, 2005).

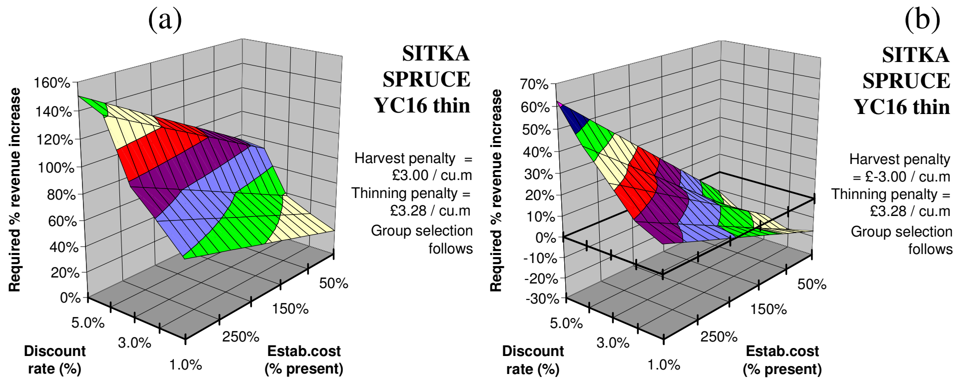
## Discounting

Discounting is the process which cost–benefit analysis uses to aggregate different time periods. It has been one of the most controversial aspects of cost–benefit analysis (Price, 1993). Its influence is pervasive in forestry and environmental economics. In evaluation of continuous cover forestry it has three particular influences, on:

1. short-term costs during transformation, versus long-term benefits – particularly if a better timber assortment can be obtained – once the new regime is in place;
2. short-term advantages of economic thinning, versus possible long-term dysgenic effects;
3. short-term costs, versus slow-in-developing environmental values.

The first effect is seen in figures 11a and 11b, which depict the required percentage improvement in revenue to cover the costs of transformation (11a), and of reverse transformation (from continuous cover forestry back to clear felling) (11b). At a high discount rate *both* may require large benefits to arise from the change, to cover the costs of felling at other-than-optimal time.

**Figure 11: Revenue requirement to compensate for costs of transformation (a) and reverse transformation (b)**




The second effect is shown in figure 12, where the dysgenic effect is of little account at high discount rates.

**Figure 12: Low discount rate and the cost of transforming by single tree selection**

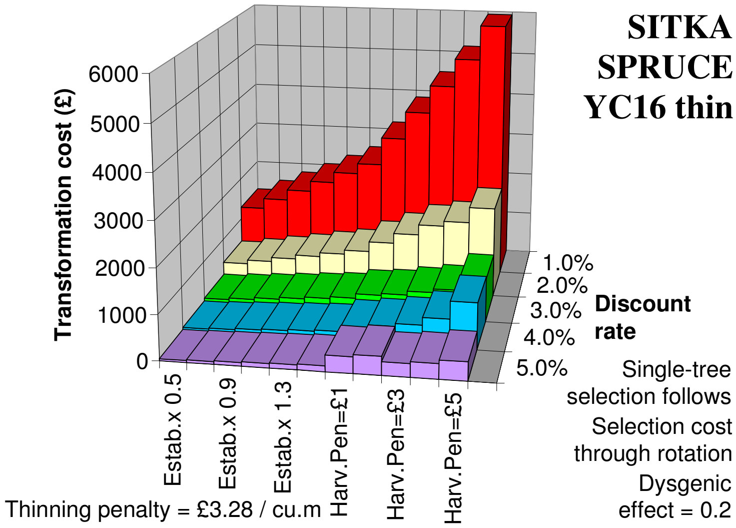



Figure 7 has illustrated the third effect.

Other authors (e.g. Hanewinkel, 2001) have noted the effect of discounting on transformation, though they do not necessarily attribute it to the same causes.

In recent years the UK Treasury (undated) has begun to advocate a tariff of discount rates that declines through time. This may or may not reflect the private discount rates that are used in long-term estate management. The effect is to give more weight than has been done by customary discounting protocols, to the longer-term effects of transformation.

## Distribution weights: aggregating across stakeholders

Distribution has been little incorporated into cost–benefit analysis as practised in the UK. While the theory is well-known, actual values to be used to adjust for distributional effects are disputed. There is no very obvious reason why there should be a strong differential distributional effect between the gainers and the losers from transformation to continuous cover forestry, unless it be in the form of subsidy – or non-subsidy – given to actors.

## Aggregating across scenarios

There has been some work on the effect of market volatility on the risk-proofing status of continuous cover forestry (Knoke et al., 2001). This presumes that transformation is advantageous, because it spaces out revenues more evenly. Equal spacing out, however, could be achieved by somewhat premature or delayed felling of an even-aged crop, and a well-distributed age-sequence of even-aged stands, once established, provides equal risk-proofing.

Continuous cover forestry may offer advantages in retarding spread of stage-specific pathogens or insects, but not the kind of advantages of "free commercial thinning" that are presented by species mixtures in even-aged stands.

## Concluding comments

The decision to favour transformation of various percentages of national forestry estates to continuous cover forestry seems to have been taken on political rather than economic – or even technical – grounds. Certainly while these decisions were being taken, time was not allowed for reflection. To propose transformation of 50% of an estate within 20 years (National Assembly for Wales, 1999), when the rotation period is in excess of 50 years, hints at a lack of understanding of the dynamics of forest stands.

The survey above suggests that there are costs as well as benefits in continuous cover forestry, compared with the baseline provided by rotational forestry. The differences, positive and negative, typically run into hundreds of pounds per hectare. But the values vary greatly with location, the version of continuous cover forestry considered, and the mode of transformation to that version. Figures for value given without specification of all these factors ought to be disregarded: they are likely to prove misleading as general results.

More research is needed, of course, but not any old research. Some research on continuous cover forestry has had a "promotional" feeling to it: the search has been for supporting evidence, rather than for the subject matter of a balanced appraisal. This project has sought to identify the relative effects of continuous cover forestry and rotational forestry, whether they are costs or benefits, and to indicate lines along which their economic evaluation might be pursued. Much remains to be done, and we do not doubt that the results produced would benefit from sceptical scrutiny.

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# Further thoughts on certification and markets

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## Abstract

Under the "polluter pays principle" of traditional environmental policy, society imposes on polluting producers a tax equal to marginal environmental damage. This is passed on as a higher consumer price for environmentally unfriendly products. By contrast, certification is seen as a way of ensuring that what people buy is what they want, and passing a higher consumer willingness to pay for environmentally friendly products to the producer. But requirements for and structure of certification in practice may not deliver the desired environmental improvements. At the same time producers see certification variously, as a means of improving public image, avoiding bad publicity, or accessing wider markets. These advantages, too, are little related to actual environmental impact. For some, certification merely authenticates existing practice, so verifiability rather than sustainability is transacted. The premium that consumers are willing to pay, translated to forest level, far exceeds any extra payment received or expected by timber growers. The idea that it represents a transaction connecting consumers with the cost and means of creating sustainable forest ecosystems is thus far-fetched. Instead, the premium should be regarded as a vote for valuing long-term environmental and social impacts of forestry explicitly, as by traditional cost–benefit analysis.

**Key words**: forest certification, green markets, cost—benefit analysis

## Introduction

At the Uppsala meeting of the Scandinavian Society of Forest Economics in 2006, the lead author presented some sceptical thoughts on the interpretation of premia for certified timber (Price, 2006). These thoughts are here pursued further, with the benefit of survey data, collected by the co-authors, from agents in the UK timber supply chain.

## "Polluter pays" versus "consumer purchases"

In the neoclassical model of the polluting firm, society should impose a tax equal to the marginal social cost of pollution on each unit produced

(Pigou, 1926). In a policy context, this came to be known as the "polluter pays" principle. Of course, the polluter is just producing the goods that consumers demand, and the cost of any pollution tax is passed on to the consumers, not through a deliberated decision of the polluters collectively, but through the operation of the market mechanism. Pigou did not believe that the market would be competent to regulate the whole process: society had to intervene to face the polluters with the full marginal cost of pollution.

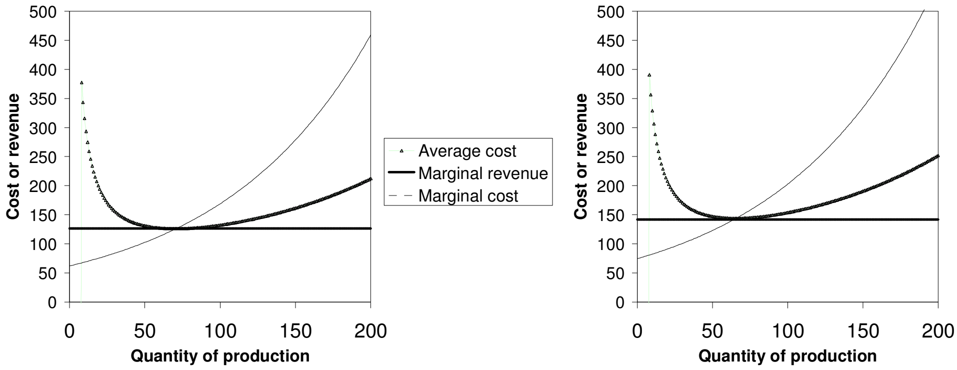


Figure 1: The classical account of social intervention for externalities: public intervention (right-hand side) raises the marginal cost curve in line with marginal cost of the externality, and equilibrium price rises also

In the real, diffuse, international world of timber production, profound difficulties arise in applying the theory:

- measuring the negative externalities of timber production that is environmentally and socially deleterious, and unsustainable;
- the variability of their incidence;
- the long time periods involved; and
- imposing and policing any such arrangement.

Hence the system has remained in the comfortable quarters of academia. Even carbon markets appear to be voluntary (polluter's conscience money?). Their instigation is chiefly driven by the perception among financial marketers, that a mark-up can be made by operating them.

The philosophy of marketing a certification premium is almost diametrically opposite.

- Price differentials originate with the consumer, not the production system.
- The consumer pays something extra, not for "polluting" timber products, but for "non-polluting" ones.
- The payment depends on the consumer's *desire* to avoid "pollution", not for the *actual* damage caused by "pollution".

- The payment is made not for each component of externalities generated, but for a certificate of assurance that a certain fixed set of standards has been met, according to the desiderata of the certifying body.

This changeover reflects a market-wards shift in political thinking. Within this way of thinking, a market is a collection of sellers and buyers of a product in contact and exchange with each other. The market mechanism is a way of directly valuing the products people want – including “the environment”. Within a market system, certification is a way of ensuring that what people buy is what they actually want (it *is* what it says on the tin), while replacing bureacratic government regulation or cost–benefit analysis by efficient market transactions.

But does this reflect the reality that is delivered by the agents involved in the certification process, as illustrated in figure 2? Examples from the process as it applies in the UK may shed some light on this.

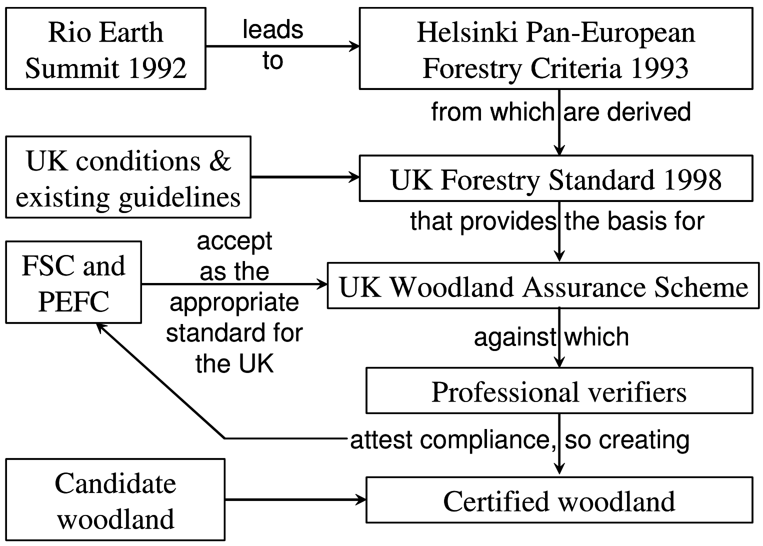

Figure 2: Agents involved in the certification process

On the face of it, the UK Government stands in a rather ambivalent position, disengaged in some respects, but engaged in others. It has no role as a legal enforcer: private individuals are at liberty to certify or not, as suits their professional judgement. The government is still, however, a dominant producer, supplying roughly half of domestic wood production. Its own plantations are certified. It is a provider of grants to compliant woodland, e.g. Better Woodlands for Wales grant requires compliance with the UK Forestry Standard, as a minimum standard, with encouragement to progress to the UK Woodland Assurance Scheme (UKWAS, 2006): i.e. the government subsidises production systems that, according to consultation processes, represent what the public wants. By contrast, it is the provider of conditional felling licences, a means of censoring unacceptable externalities. Finally, as a purchaser it exerts an influence by requiring, from 2009, public procurement to be of certified timber.

Next, what is it that is assured by the UK Forestry Standard, produced through a public consultation, and accepted by the certification bodies? Some key characteristics are as follows (Forestry Authority, 1998).

- Flexibility is granted: the owner decides on the best way to meet objectives, within certain requirements.
- 15% of area is devoted to nature conservation.
- Native species and local stock are preferred *unless* productivity is reduced. This would almost invariably be the case, so the force of this provision is uncertain.
- If it is physically possible on the site, the preference is for
  <65% of the primary species,
  >20% of the secondary species,
  >10% as open space,
  >5% of native broadleaves,
  >1% as long-term retentions.
- Lower impact systems are favoured, which again invariably have lower productivity.

The owners' motivations for entering a certification scheme in Wales (Cooper and Taylor, 2006) are shown in table 1.

Table 1: Owners' motivations for buying into certification in Wales

| Owner | Motivation | Consideration |
|---|---|---|
| Forestry Commission | Non-financial | Sustainability |
| National Trust<br>Woodland Trust<br>Royal Society for Protection of Birds | Ethical | Contribution to public image as "ethical owners" |
| Private > 500 ha | Financial | 500-1000 tonnes/year needed |
| | Price premium to pay cost of certification | £1-2 per tonne |
| | Access to markets | Avoid long transport |
| Private < 100 ha | Ethical more important | Group certification |

Owners' attitudes could be generally summarised as follows.

- Bureacratic costs often exceeded costs of compliance with the UKWAS: woodlands had often been compliant before certification.
- There was often initial over-compliance, followed by rationalisation and streamlining.
- Benefits could be derived to the enterprise: certification led to standardisation of procedures and documentation.
- There was a widespread belief that consumers do not even understand forest management, let alone certification.

Intermediaries in the supply chain had the following motivations for engagement with certified timber.

- Timber merchants sought access to markets that might be closed to non-certified supply.
- Timber processors saw supply to large retailers as sensitive to political pressure from green groups (rather than the public themselves) and to requirements of public bodies. (This did not apply to industrial timber, e.g. pallets.)
- Retailers were driven by *policy pressures* rather than *consumer demand*.

So the owners seem to be selling *approval* by a body that assures a certain standard of management. But many owners had managed to that standard previously, so only an *increased probability of sustainable management* is being sold to consumers. Some owners "sell" sustainable *forestry*, not sustainably produced *timber*. So consumers are paying for one product (timber), but actually buying another one (land management). And, as is argued below, there is almost no conception of the relationship between the amount of product and the amount of land managed in order to produce it.

Although a certain financial calculus is entailed, price premia are not generally very attractive. The "polluter" (= producer of uncertified timber) hence pays, not the measured cost of any negative externalities, but the cost as perceived by politically motivated and activated pressure groups, who, having no idea of what the actual costs of uncertified production are, implicitly attempt to impose an indefinitely high cost through an absolute proscription of uncertified timber being marketed.

Thus the primacy of the consumer within an apparently market-orientated system of purchase is compromised because what is actually being sold is

- a higher probability that the product was made through a process
- which the consumer does not understand, and which might not
- represent the products actually desired.

As argued previously (Price, 2006, 2007), it is actually very difficult to reconcile the idea of a rational self-interested consumer with what goes on in the process of purchase. Direct individual benefit from environmental improvement and greater sustainability is not a rational motivation, because of the free rider problem: almost all such effects on an individual result from decisions whether or not to buy certified timber made by all other individuals collectively. Purely altruistic motives seem implausible, and in any case are compromised by the ignorance of an individual about what it is that *other* individuals desire from certified products. The actual effects of certification are unknown, because:

- the mode of production *without* certification is uncertain (there is no assurance scheme for a base-line of "uncertifiedness", though a "controlled wood" status exists as a kind of minimum);
- it is implausible that consumers can relate the product purchased to the hectare-years required to produce it (and recall that many forest owners deliver certified *forestry* rather than certified *timber*);
- effects such as net $CO_2$ fixation are highly debated among scientists and subject to complete quantitative ignorance by consumers.

What is actually certified may not even be approved by consumers in explicit cases. For example, the UKWAS requirement, that adjacent coupes may not be felled within as much as 15 years of each other may obstruct the aesthetic redesign of the original, geometrical, compartment boundaries. The draft UK Forestry Standard stated that "Felled areas in public view should not exceed 5-10 ha." Yet the UKWAS states that "The scale and layout of plantation blocks shall be consistent with the patterns of forest stands found within the natural landscape" – which may sometimes be on the scale of many square kilometres. Where there are debates, UKWAS provides that the public are to be consulted. But *which* public, and *with what* questions? A very different implication may be taken from phrasing a question in these two different ways.

"Do you think felling should be on a small scale?"

"Do you think felling should be on a scale to match the landscape?"

The answer to the first question below will probably favour continuous cover forestry: that to the second will probably favour extensive clear felling.

"Do you think continuous cover forestry should be practised/clear felling should be forbidden?"

"Would you like to see plenty of views from the forest?"

The answer to the first question below will oppose the planting of Norway spruce: the answer to the second will favour it.

"Do you think we should plant non-native species?"

"Do you think we should do everything we can to conserve red squirrels?"

Thus a certification process based on UKWAS does not have an outcome that people would necessarily want: it does not even have a *predictable* outcome. As to timber products originating in unknown countries, whose own, different "appropriate standard" as accepted by the certifying bodies is even less known, the product of certification would be even more a mystery. In these circumstances people can hardly be characterised as purchasing a desired product.

There are even potential negative spillover effects from the acceptance of standards for certification. For example, obliging the use of less productive species or systems within one country may mean that the demand for desired products may be transferred to other, uncertified or differently-certified sources.

In circumstances where producers are not entirely producing with a profit motive, where certification may not effect much change in the actual mode of production, where consumers have little idea of the effect of their purchase on the management of forests and may not even approve of that effect, the conception of a market where producers and consumers meet to exchange a defined and desired product becomes murky and far-fetched.

To illustrate how little connection there seems to be between desire and outcome, consider the following. A 20% price premium on a product costing £25 containing 5 kg timber implies a certification mark-up of 20% × £25 = £5 for that 5 kg, which given conversion losses is probably equivalent to 10 kg of roundwood. That implies a mark-up of £500 per tonne of timber in the forest, as a willingness to pay a certification premium. The actual premium received by UK producers is around £1–2 per tonne. What happens to the other £498? Surely this cannot be the cost of operating the chain of custody! Who, then, is creaming off the profit? Who has the largest motive for certification? Why doesn't the market work to connect consumers with producers?

As I have argued before (Price, 2006), what consumers are actually doing is purchasing a warm glow, or "moral satisfaction" (Kahneman and Knetsch, 1992). Such an interpretation accords with a common-sense interpretation of the pursuit of enlightened self-interest. A warm glow is the one thing that can be assured by paying a certification premium, and cannot be achieved without paying such a premium. It is the only product that comes remotely near to achieving the conditions for a functional, value-denoting market. Answers to a direct question about motivations for buying certified timber confirmed overwhelmingly that what people want to do is "act rightly" – by the planet and by its people (see table 2).

Table 2. Motivations of a generally ethical nature (from Price, 2006)

| **Motive for buying certified timber** | **Number of responses** |
|---|---|
| That was all that was on offer, as a way of expressing concern about environmental, social justice and sustainability issues in timber production. | 5 |
| I have a general commitment to doing what I think is right. | 10 |
| I believe I should pay the full economic, environmental and social cost of what I buy. | 6 |
| One or more of the above | 14 |
| All respondents | 18 |

What is also evident is that none of these responses offer any clue as to how important are the effects of certification. Respondents wanted to express concern, but what is *the right level of concern*, given other desirable uses of resources? Respondents had a commitment to acting rightly, but *what constitutes right action* in an exceedingly complex physical and moral world? Respondents wanted to pay the full cost of what they purchase, but *how can they know what that cost is,* given that the market conveys neither the costs of "polluting" production, nor the costs of complying with "non-polluting" standards? To incorporate these desires requires a process of explicit valuation that stands apart from certification, though functioning alongside it. Consumers might not know what cost–benefit analysis is. But in a sense their stated willingness to pay for certified timber and their motives for so doing could be interpreted as a vote in favour of cost–benefit analysis, rather than as a completed valuation of certified timber. The certification premium is not a substitute for cost–benefit analysis. Far from it. It might better be regarded as a mandate for applying the method more widely.

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# Optimal Rotation under Continually – or Continuously – Declining Discount Rate

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## Abstract

It has been argued from a number of perspectives that the discount rate might decline with increasing period of discounting. With a stepped profile of decline, financially optimal rotations are quite likely to occur at a few discrete ages. For any form of declining discount rate, successor rotations will lengthen, and this will affect the optimal length of earlier rotations. But if rotation length is reassessed periodically, successor rotations will be adjusted downwards from those deemed optimal by a prior generation – a standard problem of dynamic inconsistency. This adjusted sequence of rotations will be deemed by the original decision makers to be less valuable than a sequence of lengthening rotations, and this may affect their own choice of optimal rotation. Whether, and how much, adjustment is appropriate, depends on the reasons underlying the decline of discount rates.

**Key words**: declining discount rate, optimal rotation, dynamic inconsistency

## Introduction

So much has been written about the optimal forest rotation, that it seems implausible for there to be any further aspect of the topic to explore. Yet recent interest in a schedule of declining discount rates has reopened the topic.

The effect of high discount rates on long forest rotations is particularly severe, such that investing in products like veneer oak could hardly be justified under any conventional investment appraisal. Instead, fallacious arguments have been raised which seek to link the costs of investment with revenues derived from the previous rotation (Garfitt, 1986).

An alternative avenue has been to question the whole ethical basis of discounting, particularly the discounting of *utility* or of *totalities*, as opposed to discounting of marginal consumption in a context of growing total consumption. The ethical case against discounting is especially plausible in a context of sustainable development: discounting seems the ideal means of “compromising the ability of future generations to meet their own needs” (World Commission on Environment and Development, 1987).

More recently, it has been argued from a number of perspectives that the discount rate might decline with increasing period of discounting, so that long forest investments are given advantage over other investments. Such a decline in discount rate reflects human psychological propensities (Strotz, 1956; Ainslie, 1991; Loewenstein, 1993), which may or may not be irrational. Otherwise, in general a reduced discount for longer periods can be derived by combining two or more different individual discounting profiles or protocols:

- different generations (Kula, 1981; Bellinger, 1991; Bayer, 2003; Sumaila and Walters, 2005);
- groups experiencing different income growth rates (Price and Nair, 1985);
- different goods (Price, 1993);
- different scenarios of future scarcity (Price, 1997; Gollier, 2002);
- different development paths for interest rates (Newell and Pizer, 2001);
- different perspectives on the future (Li and Löfgren, 2000).

For the purposes of this paper it does not matter much what the source of the discount profile is. Details of the process, and arguments against using the general approach, are outlined in Price (2004, 2005).

Apart from persistent instances of Kula’s rather idiosyncratic modified discounting (Kula, 1986), applications in forestry have so far been rather sparse. Hepburn and Koundouri, 2007) apply six different discounting protocols, including four with declining rates, to three representative forest investments with different rotations. From this they draw the expected conclusion: that long-term forestry investments (oak in Scotland) are more affected by declining discount protocols than are short-term ones (pine in Uganda). The urge among mainstream economists to reinvent the known results of forest economics has persisted since the times of Samuelson (1976), and still seems to be active.

While over the years much effort has been devoted to evaluating the effect of *different* discount rates on rotation, the effect of *varying* the discount rate as rotations unfold, seems to have been little examined. This paper looks at the results of applying discount rates that step downwards from time to time (continual decline), and ones that move relentlessly downwards (continuous decline). It identifies some procedural problems in calculating optimal rotations, and some problems of consistency in attempting to apply rotations calculated on such a basis.

## Stepped and fitted profiles: continual and continuous decline

Several possible profiles of discount factors with declining discount rate are shown in figure 1. The UK Treasury (undated), following guidance from OXERA (2002), which in turn was based on Newell and Pizer (2001), has advocated a schedule of discount rates "stepped" downwards periodically, as displayed in table 1.

Table 1: continually declining discount rate

| Period (years) | Discount rate |
|---|---|
| 0–30 | 3.5% |
| 30-75 | 3% |
| 75-125 | 2.5% |
| 125-200 | 2% |
| 200-300 | 1.5% |
| >300 | 1% |

The "fitted" protocol of discount rates shown below is based on regression of logarithm of discount rate on time, from this stepped sequence. The "cumulative" protocol builds up a discount factor year by year, using the discount rate scheduled for that year. Thus for, say 80 years, the discount factor would be

$$\frac{1}{1.035^{30}} \times \frac{1}{1.03^{45}} \times \frac{1}{1.025^{5}}$$

This procedure avoids the *discontinuities* in the profile displayed by the "stepped" function, although there are still *kinks* in the curve. The "conventional" protocol uses the fixed 3.5% rate with which the Treasury schedule of rates starts.

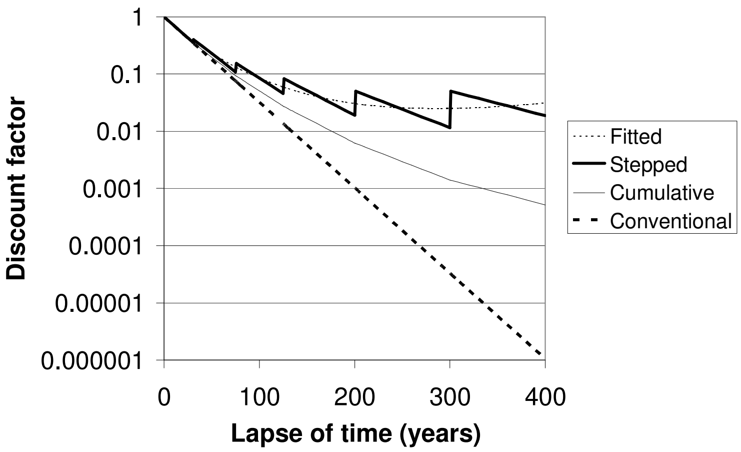


Figure 1: Four profiles of discount factors

Many other profiles might be derived from different sources (see Price, 2004 for examples). But the ones displayed suffice for demonstrating effects on forest rotations.

An hypothetical revenue function reflecting both volume growth and price–size relationship is represented in figure 2. To simplify calculations and clarify results, a no-thinning regime is adopted. Management costs are considered invariant to rotation length. This function was used, with some modification of parameters, in all subsequent modelling.

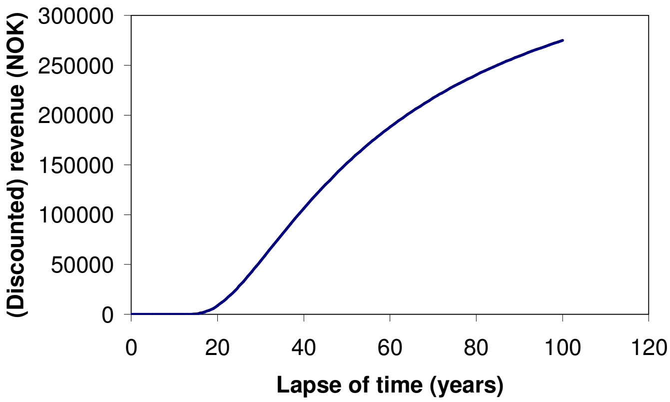


Figure 2: The basic revenue function

An optimal single financial rotation is the one maximising discounted revenue. With a stepped profile of decline, optimal single rotations generally occur at a few discrete ages. Figure 3 gives one example, typical of many. There is a local optimum at around 50 years, but maximum discounted revenue is achieved at 76 years, immediately after the discount rate steps down to 2.5%. Data labels show the optimum according to the fitted discount function, with a maximum discounted revenue of NOK 24,722 whereas according to this function the discounted revenue at 76 years is NOK 22,897. This is almost 10% lower, purely as a result of using the stepped function.

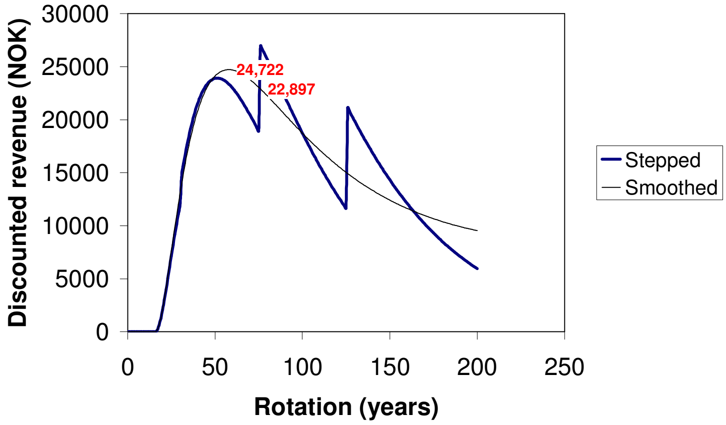


Figure 3: Stepped discounting and discrete rotation length

But the fitted function itself has problems: the discount factor *increases* beyond about 300 years. Thus it might appear desirable to extend a rotation, even if a 300-year-old crop was no longer growing. For subsequent cases, the more tractable and reasonable cumulative function is used.

## Land expectation value

Once successor rotations are included in a land expectation value (LEV), three problems arise from the lower rates that apply to later periods.

- Successive rotations become progressively longer.
- Rotations *of the same length* would have *different value*, even when discounted to their start time.
- These factors affect the future opportunity cost of land, and so influence the length of earlier rotations.

Therefore, no simple formulation for land expectation value can be constructed, by applying the usual multiplier to the NPV of a single rotation.

Instead, an incremental and numerical approach is adopted. The optimal single rotation is successively shortened, until the reduction in NPV of the present rotation is just balanced by the gain from bringing forward the NPVs of successor rotations (which represents the opportunity cost of land for a year). Note that, as rotations get shorter, subsequent rotations may move into different "discount zones", and so have to be *recalculated*, not just *brought nearer*. For example, revenues might now be discounted at a higher rate with a shortening of the successor rotation, but costs discounted at the same rate.

With the cumulative discount function, the discount rate stabilises at 301 years, and this is reflected in constant single rotations commencing thereafter, as shown in figure 4. The same would be expected for series of rotations. In fact, however, in the present calculations only ten rotations are considered. Thus, as successive rotations are initiated, there are fewer future rotations to include, so the opportunity cost of land for subsequent rotations is reduced (and reduced significantly, given the 1% discount rate in force by then). Thus for the last rotation the optimal length of a series of rotations (a series of one) is the same as for a single rotation, although the two are calculated by different processes.

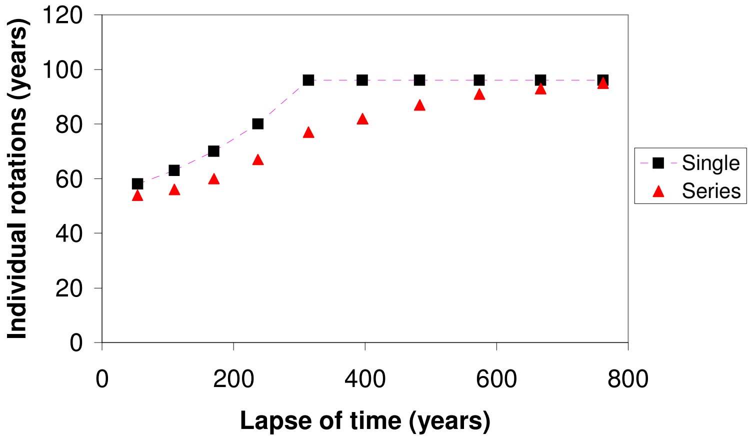


Figure 4: Optimal rotations with declining discount rate

Because the system is optimised by an iterative process in which adjacent rotations are modified in small steps, and because the discount rate changes sharply at kinks in the discount function, the search for an optimal sequence of rotations may be affected by instability. Chaotic behaviour during optimisation arises particularly with the stepped function. Optimal rotation occurs when rate of change of NPV with rotation length changes sign, and this happens several times, once at each of the steps in the discount function. A new search protocol is being developed to circumvent this problem.

Fundamentally, however, the model seems to be reliable: it generates the expected constant rotation length when a constant 3% discount rate is used.

## Dynamic inconsistency

As long as declining discount rates have been discussed, it has been observed that they will lead to “dynamic inconsistency” (Strotz, 1956). That is, a decision which appears optimal at one point in time will no longer seem so from a later point. This has led to proposals that decisions made from the present perspective should be made binding, if it is possible (Elster, 1984).

In fact, restrictive covenants or legislation have been used to lock in rotations, e.g. in Sweden and Lithuania. However, it seems unlikely that an attempt to lock in a sequence of lengthening rotations could be feasible, even for existing forests, let alone for ones yet to be planted. A particular bizarre case may be quoted from Price (2004), illustrated in table 2.

Table 2: Options for Scots pine (*Pinus sylvestris*) rotation

| Event | Cash flow per hectare | Discounted value seen from time AD 2004 | Discounted value seen from time AD 2084 |
|---|---|---|---|
| Establish | –£2000 | –£2000 | |
| Fell at age 80 | £6000 | £6000 × 0.26513 = £1591 | £6000 |
| Fell at age 120 | £12000 | £12 000 × 0.25215 = £3026 | £12 000 × 0.35653 = £4278 |

> Suppose Scots pine (*Pinus sylvestris*) is established on a low productivity site, with cash flows per hectare as shown in [table 2]. Discount factors for 40, 80 and 120 years are 0.35653, 0.26513 and 0.25215, derived by summing utilitarian and conservationist factors …. From the perspective of AD 2004, a rotation of 120 years appears profitable. However, in AD 2084 the revenue from immediate felling exceeds the discounted revenue from delaying until AD 2124. The crop is felled at age 80 years. Yet, had that felling age been anticipated at the time of establishment, the crop would not have been deemed worth planting.

Here, it would be "correct" in the perspective of the present generation to enforce a 120-year rotation. But, if the present generation claims the right of making its own decisions, why should not any future generation also claim that right? Rather than making naïve decisions based on its own preferences, the present generation should make a sophisticated decision, based on its understanding of future generations' likely preferences. It should not plant.

A further unsettling example is provided by a case modified from that shown in figure 4, with establishment cost increased to NOK 15,000. Now, as figure 5 shows, the first rotation is unprofitable, because of relatively heavy discounting between now and 58 years (≥3%) The next rotation, however, falls in a period when the discount rate changes from 3% to 2.5%, and this is sufficient to bring the second rotation into profit. Subsequent rotations, while also profitable, are sufficiently distant that their contribution to LEV declines, even though the discount rate continues to fall. Overall, LEV is positive.

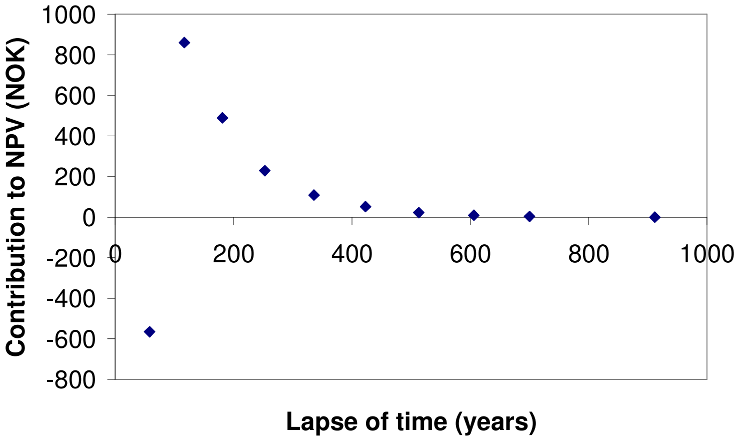


Figure 5: Change in perceived profitability between rotations

The first, naïve, instinct of the present generation might be to establish the forest, because of the positive LEV. The second instinct might be not to establish it, but to provide for its being established in 58 years' time. The third might be to predict that the second rotation will not be planted, on the same grounds as used for not planting the first. Thus every generation accepts that forestry should be the long-term use of the land, and every generation leaves it to the next to start the process.

The final instinct might be to adopt a flexible, state-dependent approach, which predicts the probability that circumstances (e.g. the track of interest rates) will change in each of a number of ways. But this is appropriate only if the change in discount rate arises from real change in circumstances, rather than from shifting time perspective. If the latter, it can confidently be predicted that future generations will make decisions in a similar self-interested and short-sighted way to the present one.

There is a problem even if the first rotation is profitable. The *most profitable* sequence of rotations, seen from the present perspective, will be adjusted to a sequence which the present generation deems *less profitable*, with the consequence that future opportunity cost is less, and its own preferred first rotation length should be longer.

## Conclusion

As was said at the outset, declining discount rates arise from combinations of two or more different discount functions. The proper way to deal with these circumstances is to incorporate these functions explicitly. For example landscape values might be discounted at a low rate on grounds advocated in Price (1973) or Fisher and Krutilla (1975). They will become progressively more important in relation to timber values, and the effect will be a successive prolongation of rotations (Calish et al., 1978), perhaps eventually reaching a stage where timber is no longer cut, or is cut in a manner that leaves forest cover intact. Yet such a protocol is based on the specifics of this particular case and its combination of products. To apply to it a set of third-hand discount rates, wheelbarrowed in from some central government office, is to misunderstand the nature of the case for giving the future greater consideration than conventional discounting would do.

When the shift in discount rate is due, not to changes attached to position in Earth history, but rather to a shifting time perspective, discounting is revealed as simply an assertion of the primacy of the present generation over all others. Although this reflects how humans think and act, it is no longer a politically fashionable position. It never *was* ethically defensible.

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# The use of Participatory Rural Appraisal and Planning to enhance local planning capacity in the buffer zone of Carrasco National Park, Bolivia

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**Abstract**
Since the 1990s, the government of Bolivia has tried to introduce the concept of co-management in protected areas but only few positive experiences have been achieved. In 2007, the government made an earmarked commitment to support this initiative by strengthening and broadening policies related to participatory planning of protected areas. This paper contributes to this objective by investigating how Participatory Rural Appraisal and Planning (PRAP) can be used as a tool to enhance local planning capacity. PRAP is a participatory method that has been widely used in research and development interventions. In order to gain a better understanding of the usefulness of PRAP in the complex Bolivian situation, four communities located in the buffer zone of Carrasco National Park – the most threatened and biodiversity-rich protected areas in Bolivia – were selected as a multiple-case study application of PRAP. The results from this study show that PRAP was useful to enhance local planning capacity by giving participants a sense of ownership to local initiatives. However, there are also limitations like that unrealistic expectations may be created in the process. The paper terminates with a discussion on the potential challenges to enhance local planning capacity by using PRAP in buffer zones of protected areas in Bolivia.

**Keywords:** PRAP; Evaluation; Capacity building; Project planning capacity; Protected areas; Bolivia

# Implications of Extreme and Mean Ratio in Near-Natural Forest Management Planning – Using a Diameter Class Modelling Approach

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**Abstract**

Near natural forest management is performed by use of domestic tree species that are able to regenerate naturally. One of the long-term key objectives is to achieve more structural richness in the form of uneven-aged mixed species forests dependent on so-called forest development types that are allocated with support in ecological mapping. A goal of perfection or an ideal structure may be sought by replication of the normal forest structure that takes the form of an inverse J-shape when analysing the stem number $ha^{-1}$ as a function of diameter. Here alternative approaches applying the extreme and mean ratio (1.61803) are developed with the purpose to describe and analyse the ideal or perfect structure of an uneven-aged forest of European beech (*Fagus sylvatica L.*) site index 1. The so-called golden ratio is applied for example in determining midpoints of diameter classes based on the assumption that the relation between the stem number $ha^{-1}$ in adjacent diameter classes is equal to the golden ratio. Solutions are found by use of Markov chains through solution of recursive equations applying linear programming. Alternative approaches where the golden ratio is applied as a structural goal are analysed.

**Keywords** Diameter class models, extreme and mean ratio, Fibonacci numbers, golden ratio, linear programming, Markov chains, modelling, near-natural forest management planning, recursive equations

## Introduction

The purpose of this paper is to explore the implications of the golden ratio (GR) within near-natural forest management planning (NNFMP).

The GR is assumed to express the ideal form or structure within many different spheres of life such as art, nature, architecture, painting, geometry etc. The arrangement of flowers and seeds in golden spirals in certain types of sunflowers making efficient use of the space available is a good example from nature of the GR. Another well-known example is the proportions of the human body. The GR is often found in well-functioning and aesthetically attractive architectural designs e.g. expressed as the relation between the height of houses in relation to the width of the street in cities. Many more examples of the presence of the GR have been presented since its recognition more than 2,000 years ago.

Pythagoras and Euclid in ancient Greece, Leonardo of Pisa, and Johannes Kepler studied the GR intensively (Livio 2002) and Fibonacci (1170-1250) mentioned the numerical series now named after him in his Liber Abaci. The first known calculation of the GR as a decimal number was described by Michael Maestlin 1597 at University of Tübingen to his former student Johannes Kepler (Wikipedia 2008).

The GR may be seen as the consequence of genetic improvement through survival of the fittest, i.e. forms or structures fulfilling the GR are more apt for our environment than alternative forms such as e.g. symmetric ones. The GR is viewed as an appealing attribute of aesthetics, which is often seen in daily life when combining aesthetical and functional qualities. E.g. the proportions of the monitor of most laptop computers fulfil the GR.

The GR may be expressed in numerical terms for various stand factor attributes such as e.g. stem number per ha, standing volume per ha, area, height and diameter as illustrated in Fig. 1 (see mathematical definitions in the Materials and Methods chapter below).

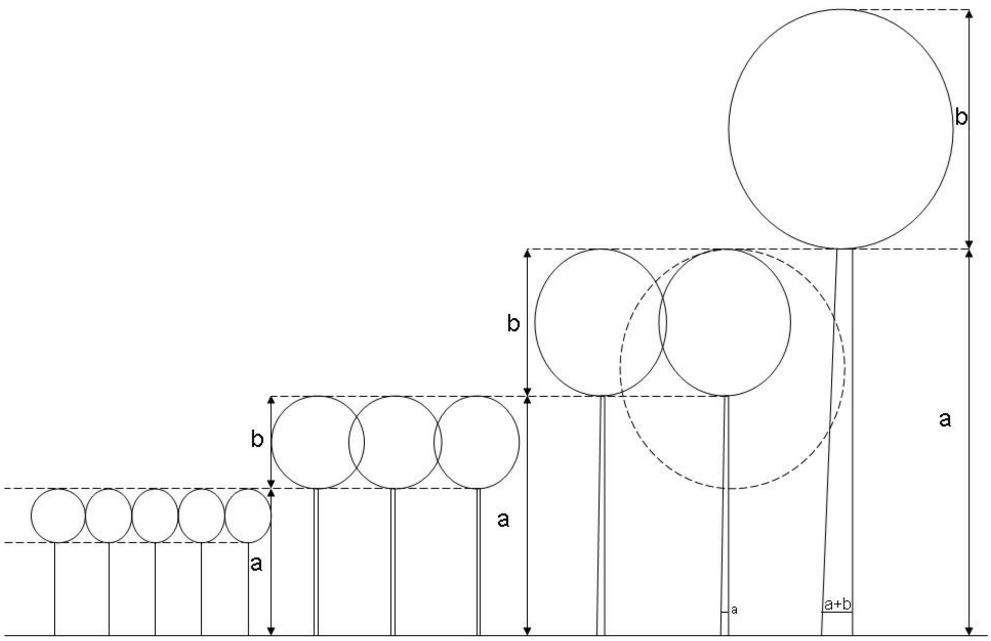


**Figure 1.** Golden ratio of stem number, height, and diameter.

The approach applied here is based on the GR of stand factor attributes being represented in adjacent diameter classes. E.g., if the stem number per ha of diameter class i is $N_i$ then the stem number per ha of diameter class $N_{i+1}$ is equal to $N_i/\varphi$, where $\varphi$ is the GR. The stem number per ha is assumed to be determined by the stem number per ha in the largest diameter class defined for beech, site index 1, at the age of 100 years. As shown in Table 1 the stem number per ha at 100 years is 131 ($4B/(\pi D^2)$, where B is basal area per ha and D is diameter – at breast height). The stem number per ha in smaller diameter classes is consequently computed recursively.

The smallest diameter class is defined such that this class includes trees with a height equal to breast height. The stem number per ha is assumed to be lower than or equal to 10,000.

The relationships between stand factor values are assumed to be in accordance with the growth and yield table data shown in Table 1. E.g., the height of a diameter class at the age of 100 years is 31.8 m, diameter is 49.3 cm, basal area is 25.0 $m^2$ per ha, stem number per ha is 131, form factor is 0.531, standing volume is 422 $m^3$ per ha, thinning harvest is 7.8 $m^3$ per ha per year, and increment is 10.1 $m^3$ per ha per year. I.e., it is implicitly assumed that the growth and the thinning regime of the forest fulfil the data shown in Table 1.

The GR may also be expressed in geometric terms as illustrated in Fig. 2 with golden rectangles or circles. The geometric representation may be applied in relation to the shape and size of e.g. regeneration harvests. The shape and size of regeneration openings could alternatively be determined as a function of tree height where the relation between tree height and the length of the side of a rectangle or the radius of a circle fulfils the GR. Interestingly, it is found that when the sides of golden rectangles and the radius of golden circles fulfil the GR then the relative size of the areas of these rectangles and circles fulfils the GR as illustrated in Fig. 2.

**Table 1.** Growth and yield table for beech, site index 1 (A=Age, H=Height, D=Diameter, B=Basal area, bh=before harvest, ah=after harvest, F=Form factor, V=Volume >5 cm, I=Increment).

| A | H | D | B | B | F | V | B | V | I |
|---|---|---|---|---|---|---|---|---|---|
| | | | bh | ah | | | H | h | |
| yrs | M | cm | $m^2$ $ha^{-1}$ | $m^2$ $ha^{-1}$ | | $m^3$ $ha^{-1}$ | $m^2$ $ha^{-1}$ | $m^3$ $ha^{-1}$ | $m^3$ $ha^{-1}$ $yr^{-1}$ |
| 4 | 0.3 | - | - | - | - | - | - | - | - |
| 5 | 0.6 | - | - | - | - | - | - | - | - |
| 6 | 1.0 | - | - | - | - | - | - | - | - |
| 7 | 1.5 | 0.9 | 0.3 | 0.3 | - | - | - | - | - |
| 8 | 1.9 | 1.2 | 0.6 | 0.6 | - | - | - | - | - |
| 14 | 4.9 | 3.6 | 5.3 | 5.3 | - | - | - | - | - |
| 18 | 6.8 | 5.5 | 12.3 | 12.3 | 0.365 | 31 | - | - | 7.7 |
| 20 | 7.8 | 6.6 | 16.7 | 13.9 | 0.454 | 49 | 2.9 | 8 | 14.7 |
| 22 | 8.8 | 7.8 | 18.1 | 14.9 | 0.485 | 63 | 3.2 | 13 | 13.4 |
| 24 | 9.8 | 8.9 | 18.8 | 15.7 | 0.491 | 75 | 3.1 | 14 | 13.0 |
| 27 | 11.2 | 10.7 | 21.1 | 16.7 | 0.493 | 92 | 4.5 | 24 | 13.6 |
| 30 | 12.6 | 12.5 | 21.5 | 17.6 | 0.495 | 110 | 4.0 | 24 | 14.0 |
| 33 | 14.0 | 14.2 | 22.0 | 18.3 | 0.497 | 127 | 3.7 | 25 | 14.2 |
| 36 | 15.3 | 16.0 | 22.3 | 19.0 | 0.499 | 145 | 3.3 | 25 | 14.3 |
| 39 | 16.6 | 17.8 | 22.6 | 19.5 | 0.502 | 163 | 3.1 | 26 | 14.4 |
| 42 | 17.9 | 19.5 | 22.9 | 20.1 | 0.504 | 181 | 2.8 | 25 | 14.3 |
| 45 | 19.1 | 21.2 | 23.2 | 20.5 | 0.507 | 199 | 2.6 | 25 | 14.3 |
| 48 | 20.2 | 22.9 | 23.4 | 21.0 | 0.509 | 216 | 2.4 | 25 | 13.9 |
| 52 | 21.7 | 25.0 | 24.5 | 21.5 | 0.511 | 238 | 3.0 | 33 | 13.8 |
| 56 | 23.0 | 27.2 | 24.8 | 22.0 | 0.513 | 259 | 2.8 | 33 | 13.5 |
| 60 | 24.3 | 29.3 | 25.0 | 22.4 | 0.515 | 280 | 2.6 | 32 | 13.1 |
| 64 | 25.4 | 31.3 | 25.2 | 22.8 | 0.517 | 299 | 2.5 | 32 | 12.7 |
| 68 | 26.4 | 33.3 | 25.4 | 23.1 | 0.519 | 317 | 2.3 | 31 | 12.3 |
| 72 | 27.4 | 35.3 | 25.6 | 23.5 | 0.520 | 334 | 2.1 | 30 | 11.9 |
| 76 | 28.2 | 37.3 | 25.9 | 23.8 | 0.522 | 350 | 2.1 | 31 | 11.5 |
| 80 | 29.0 | 39.3 | 26.0 | 24.0 | 0.523 | 365 | 2.0 | 30 | 11.2 |
| 85 | 29.8 | 41.7 | 26.8 | 24.4 | 0.525 | 382 | 2.4 | 37 | 10.9 |
| 90 | 30.6 | 44.2 | 27.0 | 24.7 | 0.527 | 397 | 2.4 | 38 | 10.6 |
| 95 | 31.2 | 46.7 | 27.2 | 24.8 | 0.529 | 410 | 2.4 | 39 | 10.3 |
| 100 | 31.8 | 49.3 | 27.3 | 25.0 | 0.531 | 422 | 2.3 | 39 | 10.1 |
| 105 | 32.2 | 51.9 | 27.5 | 25.2 | 0.533 | 433 | 2.3 | 39 | 9.9 |
| 110 | 32.7 | 54.6 | 27.6 | 25.4 | 0.534 | 443 | 2.3 | 39 | 9.8 |
| 115 | 33.0 | 57.5 | 27.8 | 25.5 | 0.536 | 451 | 2.3 | 41 | 9.8 |
| 120 | 33.3 | 60.5 | 27.9 | 25.6 | 0.538 | 458 | 2.3 | 41 | 9.8 |
| 125 | 33.6 | 63.6 | 28.0 | 25.7 | 0.540 | 465 | 2.3 | 42 | 9.8 |
| 130 | 33.8 | 66.9 | 28.1 | 25.7 | 0.543 | 472 | 2.4 | 43 | 9.9 |
| 135 | 34.0 | 70.3 | 28.2 | 25.8 | 0.544 | 477 | 2.4 | 44 | 10.0 |
| 140 | 34.1 | 73.7 | 28.3 | - | 0.546 | 528 | - | | |

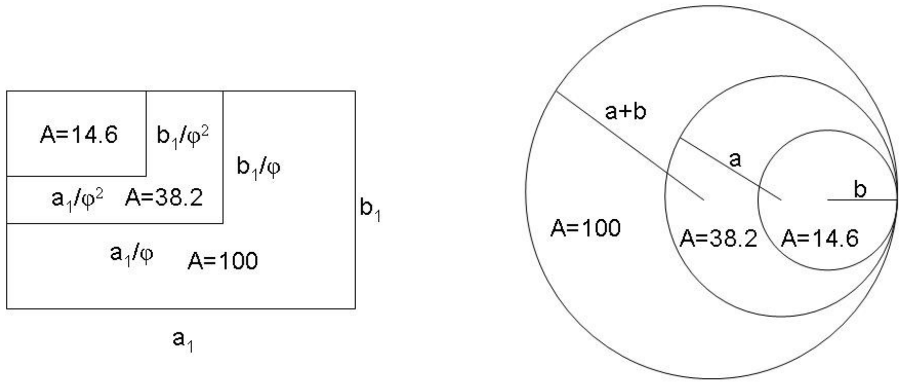


**Figure 2.** Golden rectangles and circles. (A=area.)

## Material and Methods

The GR is defined as the proportion of a to b where a is to b as (a+b) is to a. The numerical value is the solution to the equation

$$\frac{a+b}{a} = \frac{a}{b} = \varphi = \frac{1+\sqrt{5}}{2} = 1.61803398874989 \quad (1)$$

The implications of the GR defining the ideal structure of the forest are analysed assuming that the following relative stand factor values in adjacent diameter classes is equal to φ:

1) Stem number per ha (N).
2) Standing volume per ha (V).
3) Area (A) – decreasing (A-) and increasing (A+).
4) Height (H).
5) Diameter (D).

The growth and yield table of Moeller (1933) that is applied in a slightly modified form in Anon. (2003) is applied for beech, site index 1 as shown in Table 1.

The growth of beech is modelled as a Markov chain using the following equation

$$\mathbf{p_t} = \mathbf{p_{t-1}P}\text{, for t=1,…,T} \quad (2)$$

where

$\mathbf{p_t}$ is the state vector defined by the diameter distribution in terms of the number of trees per unit area in different size classes at time t

**P** is the transition probability matrix of trees between states of trees

T is the number of periods in a projection

The target diameter is represented by the midpoint diameter of the largest diameter class i.e. 49.3 cm at the age of 100 years (see Table1).

The relative area distribution to diameter classes is computed recursively by solution of formula 2 where the transition probabilities determine the area distribution to diameter classes assuming steady state. The solution to the corresponding set of n recursive equations (n = number of diameter classes) is obtained by application of linear programming (LP) hereby assuring sustainability of the optimal solution.

The size of the regeneration harvest is computed by use of the transition probability estimated for the largest diameter class.

The Berger-Parker index is viewed as one of the most satisfactory indices of diversity (Berger & Parker 1970). It is defined as:

$$BP_i = \frac{\sum_{i=1}^{N} A_i}{Max(A_i)} \qquad (3)$$

where

$A_i$ proportion of area in diameter class i

N number of diameter classes

The maximum value of the index is found when the distribution to classes is even. In this case the value is equal to N. The minimum value is 1 representing no diversity with the entire area is found in one single class.

## Results

The solutions fulfilling the GR with respect to stem number per ha (N), standing volume per ha (V), decreasing area distribution (A-), increasing area distribution, height (H), and diameter, - in adjacent diameter classes, respectively, are shown in Table 2 and illustrated in Figs. 3-8. The characteristics of the normal forest (NF) are given as reference.

**Table 2.** Diameter class midpoint (DC), stem number per ha (N), area (AR), height (H), standing volume per ha (V), age (A), annual thinning volume per ha (TV), and annual target diameter harvest volume per ha (TD) – by diameter class - for GR structural strategies (S): stem number (N), volume (V), decreasing area (A-), increasing area (A+), height (H), diameter (D), and normal forest (NF). The Berger-Parker index (BP) of each strategy is shown in the first column. (Total=T, mean=M.)

| BP | DC | N | AR | H | V | A | TV | TD |
|---|---|---|---|---|---|---|---|---|
| | cm | $ha^{-1}$ | ha | m | $m^3$ $ha^{-1}$ | yrs | $m^3$ $ha^{-1}$ $yr^{-1}$ | $m^3$ $ha^{-1}$ $yr^{-1}$ |
| S | N | | | | | | | |
| 4.7 | 1.9 | 555.4 | 0.056 | 2.8 | 0.0 | 9.6 | 0.0 | |
| | 4.3 | 275.2 | 0.045 | 5.4 | 0.0 | 14.3 | 0.0 | |
| | 6.8 | 170.1 | 0.045 | 7.8 | 2.2 | 19.9 | 0.2 | |
| | 9.3 | 117.0 | 0.050 | 10.0 | 4.0 | 24.5 | 0.4 | |
| | 12.3 | 94.1 | 0.065 | 12.6 | 7.1 | 30.0 | 0.5 | |
| | 16.5 | 74.3 | 0.083 | 15.9 | 12.5 | 37.2 | 0.7 | |
| | 21.5 | 62.2 | 0.112 | 19.4 | 22.8 | 45.9 | 0.9 | |
| | 28.9 | 49.8 | 0.145 | 24.0 | 40.2 | 59.0 | 1.2 | |
| | 37.6 | 39.4 | 0.186 | 28.2 | 64.7 | 76.0 | 1.4 | |
| | 49.6 | 28.2 | 0.215 | 32.0 | 91.6 | 101.6 | 1.7 | 4.1 |
| T/M | 27.5 | 1,465.5 | 1.000 | 21.1 | 245.1 | 58.0 | 7.0 | 4.1 |
| S | V | | | | | | | |
| 2.7 | 2.1 | 209.7 | 0.021 | 1.3 | 0.0 | 6.7 | 0.0 | |
| | 2.9 | 209.7 | 0.021 | 2.1 | 0.1 | 8.3 | 0.0 | |
| | 3.8 | 183.4 | 0.018 | 2.8 | 0.1 | 9.9 | 0.0 | |
| | 4.6 | 103.7 | 0.016 | 3.5 | 0.1 | 11.4 | 0.0 | |
| | 5.5 | 25.6 | 0.005 | 5.8 | 0.1 | 15.9 | 0.0 | |
| | 5.8 | 33.7 | 0.007 | 6.3 | 0.2 | 16.9 | 0.0 | |
| | 6.3 | 59.5 | 0.014 | 7.2 | 0.5 | 18.7 | 0.0 | |
| | 7.5 | 112.9 | 0.034 | 8.8 | 2.1 | 22.0 | 0.2 | |
| | 10.5 | 160.1 | 0.084 | 11.7 | 8.4 | 28.1 | 0.7 | |
| | 17.8 | 110.7 | 0.141 | 16.5 | 22.8 | 38.7 | 1.2 | |
| | 27.9 | 96.6 | 0.268 | 23.1 | 69.8 | 49.5 | 2.2 | |
| | 50.7 | 45.9 | 0.371 | 31.8 | 156.7 | 100.3 | 2.8 | 3.6 |
| T/M | 30.3 | 1,351.5 | 1.000 | 22.0 | 260.8 | 60.2 | 7.1 | 3.6 |
| S | A- | | | | | | | |
| 2.6 | 20.2 | 248.4 | 0.390 | 18.5 | 73.7 | 43.5 | 3.2 | |
| | 32.6 | 66.4 | 0.241 | 25.9 | 74.6 | 66.0 | 1.9 | |
| | 40.3 | 28.4 | 0.149 | 29.3 | 54.8 | 81.6 | 1.1 | |
| | 45.1 | 14.2 | 0.092 | 30.9 | 36.8 | 91.0 | 0.7 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 48.0 | 7.8 | 0.057 | 31.6 | 23.8 | 96.3 | 0.4 | |
| | 49.8 | 4.5 | 0.035 | 32.0 | 15.0 | 99.2 | 0.3 | |
| | 51.0 | 2.7 | 0.022 | 32.2 | 9.4 | 104.4 | 0.2 | |
| | 51.7 | 1.6 | 0.013 | 32.4 | 5.9 | 105.8 | 0.1 | 2.2 |
| T/M | 32.2 | 373.9 | 1.000 | 24.7 | 294.2 | 66.1 | 8.0 | 2.2 |
| S | A+ | | | | | | | |
| 2.6 | 0.7 | 134.4 | 0.013 | 1.5 | 0.0 | 7.1 | 0.0 | |
| | 1.8 | 217.5 | 0.022 | 2.8 | 0.0 | 9.8 | 0.0 | |
| | 3.6 | 283.0 | 0.035 | 4.7 | 0.0 | 13.7 | 0.0 | |
| | 6.6 | 231.1 | 0.057 | 7.6 | 2.5 | 19.5 | 0.2 | |
| | 11.3 | 154.6 | 0.092 | 11.8 | 9.2 | 28.2 | 0.7 | |
| | 19.0 | 104.5 | 0.149 | 17.7 | 26.4 | 41.6 | 1.2 | |
| | 31.5 | 70.5 | 0.241 | 25.4 | 72.4 | 64.3 | 1.9 | |
| | 51.7 | 46.7 | 0.390 | 32.4 | 170.4 | 105.8 | 3.1 | 2.2 |
| T/M | 32.2 | 1,242.3 | 1.000 | 23.1 | 280.9 | 67.5 | 7.2 | 2.2 |
| S | H | | | | | | | |
| 2.4 | 0.5 | 89.8 | 0.009 | 1.1 | 0.0 | 6.1 | 0.0 | |
| | 1.1 | 145.3 | 0.015 | 1.8 | 0.0 | 7.6 | 0.0 | |
| | 2.0 | 309.9 | 0.041 | 2.9 | 0.0 | 10.0 | 0.0 | |
| | 4.7 | 180.1 | 0.029 | 4.6 | 0.0 | 13.6 | 0.0 | |
| | 6.6 | 200.0 | 0.049 | 7.5 | 2.1 | 19.4 | 0.2 | |
| | 11.0 | 223.2 | 0.127 | 12.1 | 13.3 | 29.0 | 1.0 | |
| | 23.0 | 154.7 | 0.305 | 19.7 | 63.2 | 46.5 | 2.5 | |
| | 50.5 | 53.0 | 0.425 | 31.8 | 179.5 | 100.0 | 3.3 | 3.5 |
| T/M | 30.4 | 1,356.0 | 1.000 | 21.7 | 258.1 | 62.3 | 7.0 | 3.5 |
| S | D | | | | | | | |
| 3.1 | 0.6 | 104.8 | 0.010 | 1.3 | 0.0 | 6.5 | 0.0 | |
| | 1.0 | 94.3 | 0.009 | 1.7 | 0.0 | 7.6 | 0.0 | |
| | 1.7 | 143.8 | 0.014 | 2.5 | 0.0 | 9.2 | 0.0 | |
| | 2.7 | 174.5 | 0.023 | 3.7 | 0.0 | 11.8 | 0.0 | |
| | 4.4 | 308.9 | 0.047 | 5.5 | 0.0 | 15.4 | 0.0 | |
| | 7.2 | 216.1 | 0.061 | 8.1 | 3.3 | 20.6 | 0.3 | |
| | 11.6 | 158.4 | 0.099 | 12.0 | 10.2 | 28.7 | 0.8 | |
| | 18.8 | 113.9 | 0.159 | 17.6 | 27.9 | 41.2 | 1.3 | |
| | 30.5 | 79.8 | 0.258 | 24.8 | 75.1 | 62.3 | 2.1 | |
| | 49.3 | 41.5 | 0.319 | 31.9 | 135.4 | 101.0 | 2.5 | 3.8 |
| T/M | 28.5 | 1,435.9 | 1.000 | 21.5 | 251.9 | 60.2 | 7.0 | 3.8 |
| S | NF | | | | | | | |
| 10.0 | 4.3 | 687.0 | 0.100 | 5.3 | 0.0 | 15.2 | 0.0 | |
| | 9.3 | 233.6 | 0.100 | 10.0 | 8.0 | 24.6 | 0.7 | |
| | 14.3 | 114.5 | 0.100 | 14.2 | 12.9 | 34.0 | 0.8 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 19.3 | 68.5 | 0.100 | 17.9 | 18.0 | 43.4 | 0.8 | |
| | 24.3 | 45.9 | 0.100 | 21.2 | 23.2 | 52.9 | 0.8 | |
| | 29.3 | 33.1 | 0.100 | 24.2 | 28.1 | 62.3 | 0.8 | |
| | 34.3 | 25.3 | 0.100 | 26.8 | 32.3 | 71.7 | 0.8 | |
| | 39.3 | 19.9 | 0.100 | 28.9 | 36.1 | 81.1 | 0.8 | |
| | 44.3 | 15.9 | 0.100 | 30.6 | 39.5 | 90.6 | 0.8 | |
| | 49.3 | 13.1 | 0.100 | 31.9 | 42.5 | 100.0 | 0.8 | 4.5 |
| T/M | 26.8 | 1,256.8 | 1.000 | 21.1 | 240.4 | 57.6 | 7.1 | 4.5 |

The number of diameter classes for the different distribution strategies varies between 8 for the A strategies and the H strategy to 12 for the V strategy.

The A strategies have the largest mean diameter of 32.2 cm and the NF strategy the smallest of 26.8 cm.

The greatest diameter class width of mature or near-mature trees is observed for the H strategy, which is not surprising because a height increase corresponding to the GR is relatively large when the height is large. The largest distance between diameter midpoints is found for the H strategy. See Fig. 3.

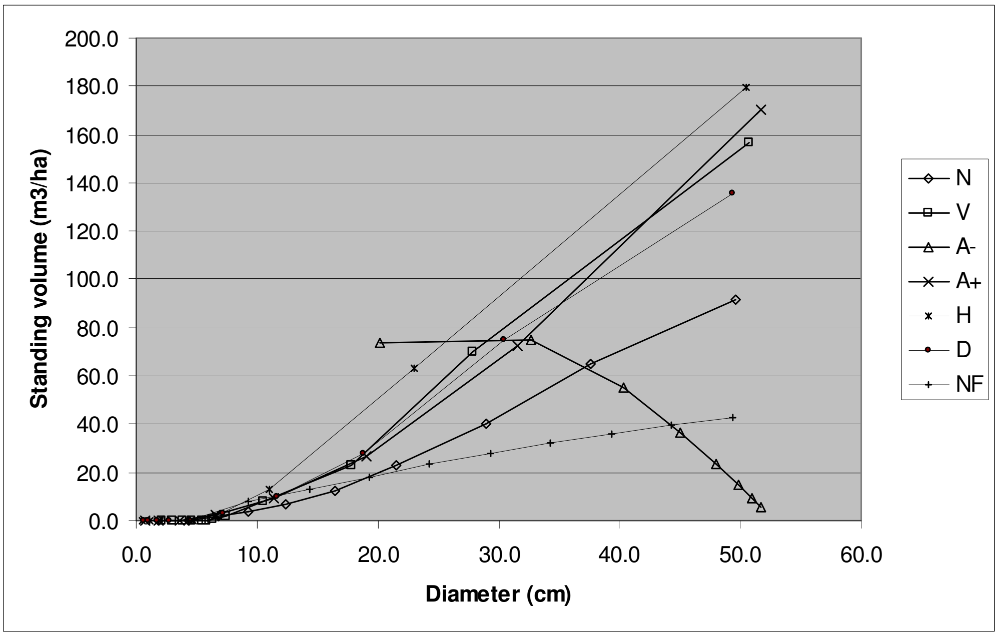


**Figure 3.** Standing volume per ha by diameter class.

The largest diameter class width of small trees is observed for the A-strategy where the area in the smallest diameter class and the next smallest fulfils the GR.

The stem number per ha fluctuates between a minimum of 374 for the A- strategy to 1,466 for the N strategy. Fig. 4 shows that the N strategy and NF strategy have a high stem number per ha because there are many small diameter classes in the N strategy and the NF strategy comprises relatively large area proportions of small diameter classes.

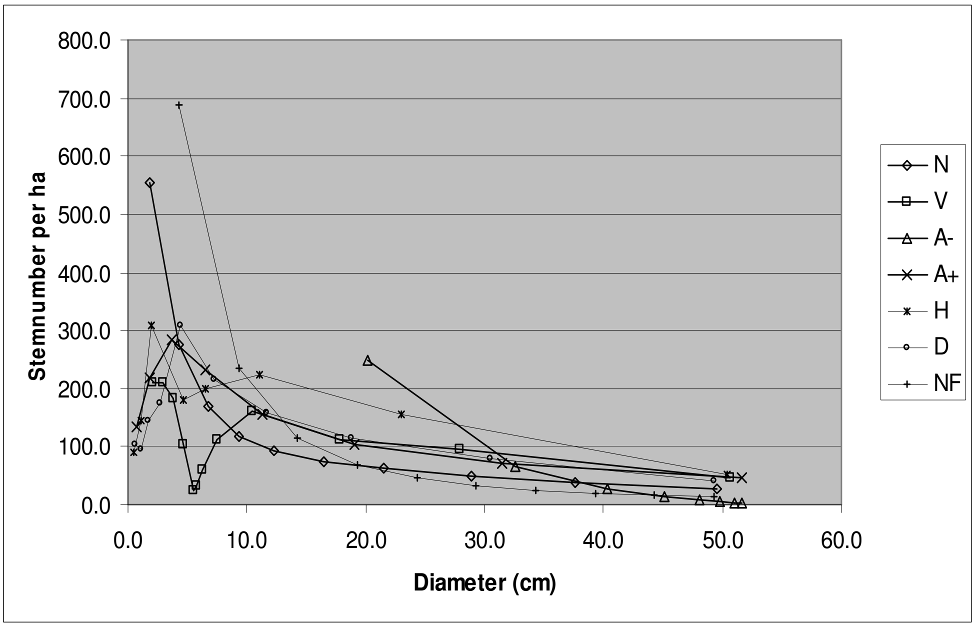


**Figure 4.** Stemnumber per ha by diameter class.

The area distributions are characterised by an overweight of large diameter classes except for the A- strategy with 1.3 per cent in the largest diameter class. The proportion of the largest diameter class of the remaining strategies varies between a maximum of 43 per cent for the H strategy and a minimum of 22 per cent for the N strategy. See Table 2 and Fig. 5. Fig. 5 also shows that the largest proportion of area in the mature and near-mature diameter classes is found for the H strategy.

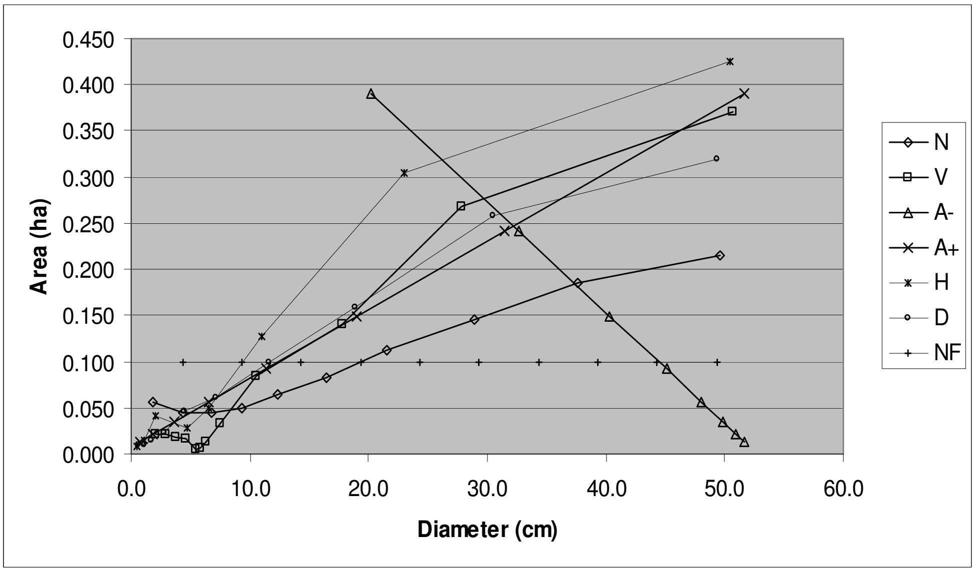


**Figure 5.** Area distribution by diameter class.

The area-weighted height varies from a minimum of 21.1 m for the N strategy to a maximum of 24.7 m for the A- strategy caused by a large mid-diameter of the smallest diameter class of this strategy.

The A- strategy results in the highest standing volume per ha of 294 $m^3$ $ha^{-1}$ and the lowest is 245 $m^3$ $ha^{-1}$ for the N strategy (the reference, NF, has a standing volume of 240 $m^3$ $ha^{-1}$). The high standing volume of the A- strategy is attributed to a relatively high standing volume in the small to medium diameter classes. See Figs. 3 and 8.

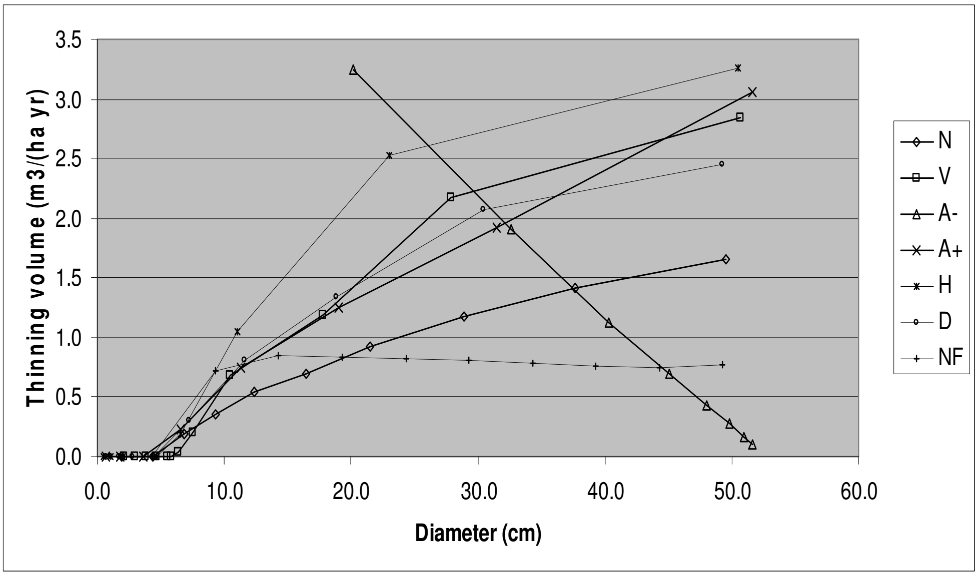


**Figure 6.** Thinning volume by diameter class.

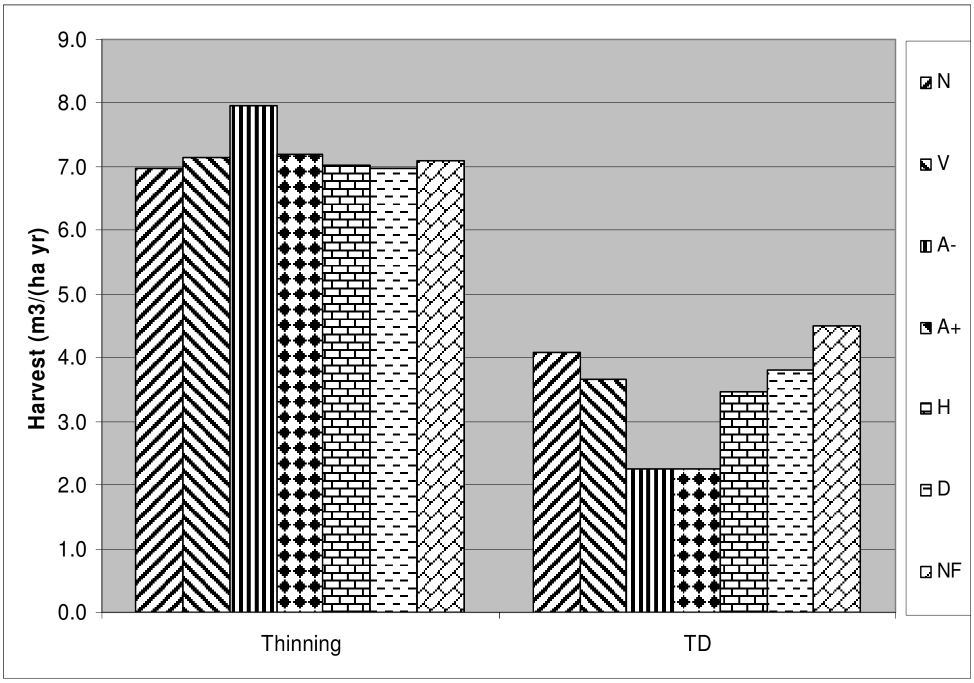


**Figure 7.** Total thinning and target diameter (TD) harvest per ha per year.

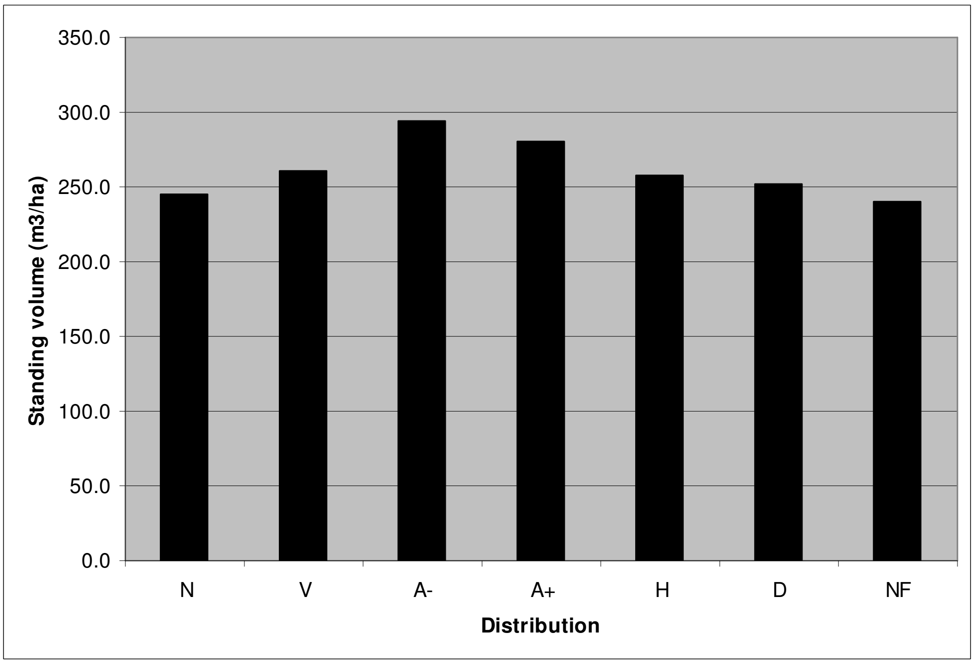


**Figure 8.** Total standing volume per ha.

The A+ strategy will result in the structure with the highest mean age of 68 years whereas the youngest forest with a mean age of 58 years is obtained when using the N strategy (the mean age of the NF reference strategy is also 58 years). The high mean age of the A+ strategy is attributed to the large and growing proportion of mature and near-mature diameter classes.

The largest thinning volume per ha per year of 8.0 $m^3$ $ha^{-1}$ is achieved by the A- strategy because the area proportions of medium to small diameter classes dominate and the size of target diameter regeneration harvest volume is relatively small. This result is caused by the small proportion of mature and near-mature diameter classes. The thinning volume per ha per year does not differ much among the remaining strategies with an annual thinning volume per ha of around 7.0 $m^3$ $ha^{-1}$. See Fig. 7.

Fig. 7 also shows that the A- and A+ strategies result in the smallest regeneration harvest of 2.2 $m^3$ $ha^{-1}$ $year^{-1}$ and the N strategy in the largest at 4.1 $m^3$ $ha^{-1}$ $year^{-1}$ (the regeneration harvest volume of the NF reference strategy is 4.5 $m^3$ $ha^{-1}$ $year^{-1}$).

## Conclusion

The stem number distribution following from the N strategy characterised by the stem number per ha of adjacent diameter classes fulfilling the GR does not comply with the GR itself because the area distribution is uneven – as a consequence of the steady state requirement of the solution. The strategy results in an overweight of large diameter classes parallel to the majority of the remaining strategies. E.g., the relative stem number per ha is 2.02 (555/275) for diameter classes 1 and 2 and 1.40 (39.4/28.2) for diameter classes 9 and 10.

The A- strategy is an outlier in terms of most of the stand factors. It may, therefore, be questioned whether this strategy is realistic or attractive? The most conspicuous attribute is that the proportion of the smallest diameter class is 39 per cent with a mean height of 18.5 metres and a diameter of 20.2 cm. The strategy is realistic because the mean residence time of this extremely wide diameter class covering 39 per cent of the area is 76 years and the transition probability of moving to the next larger diameter class is equal to 0.01316 assuming a period length of 1 year. Similarly, the mean residence time of the largest diameter class, which covers 1.3 per cent of the area, is 2.6 years because the transition probability that a tree in this class moves into the smallest diameter class - interpreted as regeneration harvest – is 0.3819. Due to the fact that the largest proportion of the thinning volume comes from the smallest diameter class it is likely that this strategy performs poorly when applying the profitability criteria of maximizing the land expectation value.

The H strategy is assumed to be the most appealing from a physical or aesthetic point of view because the relative height of adjacent diameter classes fulfils the GR. However, the area distribution is dominated by the large diameter classes parallel to most of the other strategies – 32 per cent is covered by the largest diameter class and only 1 per cent by the smallest diameter class.

The H and A+ strategies are the most capital intensive because the area distribution is dominated by large diameter classes that hold large amounts of valuable volume. The standing volume per ha in the largest diameter class amounts to 180 and 170 $m^3$ $ha^{-1}$, respectively, corresponding to 70 and 61 per cent of the total standing volume (see Table 2). The distribution obtained by use of the V strategy is less capital intensive because the standing volume in the largest diameter class is lower than that of the A+ strategy and the regeneration harvest of the V strategy is more than 50 per cent larger.

The relative age of adjacent age classes of the D strategy approaches the GR as the age increases. If the age is adjusted by the age at breast height of 6.1 years then the GR is approximately fulfilled for the relation between diameter and age (see Table 2). E.g., the relation between the diameters of 7.2 cm and 4.4 (1.64) is approximately as the relation between the ages above breast height of 14.5 years (20.6 – 6.1 years) to 9.3 years (15.4 – 6.1 years) (1.56), i.e. approximately the GR. The GR is expressed more closely for the two largest diameter classes. The ratio of diameter mid-point values is 1.6164 and the ratio of the breast height adjusted ages is equal to 1.6886 ((101 – 6.1) years/(62.3 - 6.1 years)). The reason is that the thinning regime implies an approximate linear relationship between age and diameter.

The best performing strategy with respect to diversity is the N strategy with a weighted (by number of diameter classes) BP index of 0.47 (see Table 2) and the lowest diversity is obtained by use of the H strategy with a weighted BP index of 0.24. The NF reference strategy naturally comprises maximum diversity with a weighted BP index of 1.000. It is concluded that the best performing strategy for a forest owner emphasizing ecological objectives is the N strategy.

The proportion of annual regeneration areas for the six strategies is: 0.95 per cent (N), 0.43 per cent (V), 0.51 per cent (A- and A+), 0.82 per cent (H), 0.90 per cent (D), and 1.06 per cent (NF reference), which indicate that the N strategy implies the highest rate of regeneration establishment and consequently the highest regeneration costs per ha per yr.

## Discussion

The results described above are based on the assumption of the silvicultural treatment encompassed in Table 1.

An alternative approach consists of seeking a strategy based on the assumption of fulfilling the GR of a given stand factor while adjusting the silvicultural treatment. This approach has been applied for stem number (N). I.e., it is assumed that N in adjacent diameter classes fulfils the GR. Thinning volume is derived from the resulting N reduction per period where the diameter of thinning is assumed to be 0.9 times the diameter of the stand before thinning. A fixed period length of 10 years is assumed. The Eichorn rule is assumed, i.e. the total volume production is a function of height alone. The form factors applied as a function of height as shown in Table 1 are assumed.

Based on these assumptions it is found that the diameter growth is strongly affected by the stem number per ha in the largest diameter class, when this stem number is selected as the final goal of the distribution characterized by the GR. E.g., when the stem number per ha following from the data in Table 1 at the age of 140 years (66) is chosen as the goal for the largest diameter class then the diameter of the largest diameter class is equal to 42.4 cm. This is not realistic in terms of target diameter. A minimum target diameter of 50 cm is assumed to be realistic.

It is found that the target diameter is highly sensitive to the stem number per ha in the smallest diameter class. Therefore, the stem number distribution fulfilling the GR is alternatively constructed on the basis of the initial stem number – in the smallest diameter class, instead of the final stem number – in the largest diameter class. The criteria for the stem number per ha in the smallest diameter class is that the stem number should be in the interval from 5,000-10,000 per ha. The regeneration stem number based on planting according to Anon. (2003) is 5,600.

Natural regeneration establishment is assumed to be initiated when the basal area becomes lower than 19 $m^2$ $ha^{-1}$. Based on the approach above, it is found that the age of natural regeneration is independent on the initial stem number per ha, when the stem number in the lowest diameter class is in the interval from 5-10,000 per ha. Natural regeneration starts at the age of 64 years (with basal area = 19 $m^2$ $ha^{-1}$). However, the target diameter is obtained earlier (at a lower age) when the stem number per ha in the smallest diameter class is small. Assuming an initial stem number of 10,000 per ha results in a target diameter of approximately 50 cm obtained at the age of 115 years. An initial stem number of 5,000 per ha results in a target diameter of 50 cm at the age of around 99 years. The minimum basal area over the age of 64 years is in this case 15 $m^2$ $ha^{-1}$, which makes the assumption of the Eichorn rule questionable because the growth and yield of beech is reduced considerably when the basal area is lower than approximately 22.5 $m^2$ $ha^{-1}$ (Tarp et al. 2005). However, the relationship between basal area and growth is not linear. E.g., a basal area reduction from 22.5 $m^2$ $ha^{-1}$ to 20.3 $m^2$ $ha^{-1}$ (10 per cent) results in a growth reduction of less than 10 per cent.

The GR may be represented vertically by comparison of tree height with stem height. Obviously, relative stem height is dependent on thinning intensity. The stronger the thinning intensity the lower the relative stem height. Henriksen (1988) presents a summary of Danish thinning experiment data where the relative stem height is approximately 40 per cent when the applied thinning intensity corresponds to 50 per cent of the maximum basal area (50 $m^2$ $ha^{-1}$). The site index is approximately 1 and may therefore be compared with the data in Table 1. It is seen that the thinning intensity applied by Anon. (2003) corresponds to a relative basal area of approximately 50 per cent – from 21.5 to 25.8 $m^2$ $ha^{-1}$ in the age interval from 50 to 140 years. The relative stem height reflected by the thinning regime is in accordance with the GR in the sense that the ratio of tree height to crown height is approximately the GR (100/60 = 1.67). The stem height/crown height data of Henriksen (1988) seem to be independent of age for the thinning regime described above, with a ratio of height to crown height at 1.63 at 38 years, 1.59 at 68 years, and 1.61 at 87 years. If the thinning regime depicted in Table 1 is normal and common in practice, then it is concluded that the GR is reflected in the goal of practical forest management. The vertical tree form obtained by application of the regime represents the GR as illustrated in Fig. 1 on tree number two from the right with the crown height marked with a dashed line. However, as illustrated by e.g. Larsen & Nielsen (2007) the crown form of a managed beech forest is normally longitudinal, i.e. the crown height is longer than the crown width, rather than circular.

Zelic (2006) found that the diameter growth of beech in Croatia as a function of age follows the golden section. This result is confirmed by the analyses of the D strategy above for beech in Denmark.

Future research with alternative approaches concerning the implications of the GR with respect to the different stand factors could potentially contribute to improved forest management through formulation of new thinning/harvesting regimes and guidelines. E.g., the scenario described above with a rotation age of around 99 years may be realistic but an economic evaluation would be desirable. Investigation of the economic implications is, however, beyond the scope of this paper. The approach may be constructive in analysing the structural characteristics of forest development types as outlined by Larsen & Nielsen (2007).

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# International market establishment among small and medium sized Swedish furniture producers

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**Abstract**

Small and medium sized enterprises (SMEs) are vital for a country's economy considering export growth, creation of job opportunities, and general economic development (Mtigwe, 2005). Thus, acknowledging the societal importance of SMEs in general and internationalization of SMEs in particular, it is puzzling how little research attention this area attracts. One reason why few internationalization studies focus on SMEs is that international involvement is a resource-demanding activity, and most SMEs operate under tight resource constraints resulting in low freedom of action. Among SMEs that are involved in international business, export is often the preferred entry mode. In this research, export is included as the entry strategy component of the international establishment model called *the modified PSE model*. Since the original PSE model was developed for large corporations entering emerging markets, it has been altered to fit SMEs entering foreign markets through export. The modified PSE model is based on four components: perception of internationalization barriers; strategy competence; entry strategy; and performance. All empirical material for this study will come from small and medium sized furniture producers in Sweden. Along with a theoretical discussion, this conference paper includes a presentation of the research model, sample frame, and research design.

Keywords: SME, furniture producer, perception of internationalization barriers, strategy competence, export, and performance.

**Introduction**

Regardless of company size, international involvement has become more and more essential for survival and growth (Axinn and Matthyssens, 2002; Chetty and Campbell-Hunt, 2003; Coviello and McAuley, 1999; Minifie and West, 1998). Thus, from the perspective of small and medium sized enterprises (SMEs)[5], international involvement is highly important as it

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[5] For a firm to be considered a small and medium sized enterprise the following requirements must be met (European Commission, Enterprise and Industry Publications):

enables, at the lowest level, meeting the tough international competition. Further, as the globalization effects on any firm are becoming more and more evident and unavoidable, even the non-exporter can feel the pressure from international competitors.

*"During the last decades, the global business scene and the European one in particular have enhanced international competition affecting both enterprises with an export profile and enterprises focusing on the domestic market."* (European Commission, 2003, pp. 9)

Being internationally active is not only important on the individual business level, but also on a national level. Existing research have found that SMEs are key to develop export growth, employment opportunities, and therefore positively contributes to the general economic development of the country (Mtigwe, 2005). For example in EU, 99 percent of all firms are SMEs, providing 75 million job opportunities and accounting for two thirds of the jobs in the private sector (European Commission, 2006). Further, between 2005 and 2006 these European SMEs increased their export by 12 percent (European Commission, 2007).

Considering how critical international business is on both firm and country levels, little research has, until recently, been focused on internationalization among SMEs. The small size of these firms and their limited access to resources are mentioned as the main reasons for the neglect (Holmlund and Kock, 1998; Zacharakis, 1997). Moreover, existing research on SMEs is often based on older theories (Axinn and Matthyssens, 2002) developed for larger firms (Coviello and McAuley, 1999, Chetty and Campbell-Hunt, 2003). In conclusion, more and updated research on international establishment among SMEs is necessary.

This research on internationalization among SMEs is conducted within the framework of an international establishment model called the PSE model. The PSE model comprises the three interrelated components of perception of entry barriers; strategy competence; and entry strategy.

First presented in 2001 (Pehrsson, 2001) the model was developed as a reaction to existing international market entry research that was being too tied to either the school of industrial organization (IO) or the resource based view (RBV) (Pehrsson, 2002). Considering the simultaneous importance of external and internal factors for a firm's international approach, one strength of the PSE model lies in its inclusion of both these elements. Another benefit of the model is the compact and well-defined

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Have fewer than 249 employees, an annual turnover not exceeding 50 million EURO, and not be owned to 25 percent or more by a partner.

structure that frames the research without forcing set rules onto the empirical setting to be studied.

However, the PSE model was developed for large telecommunication operators active in internationally emerging markets[6], and as a result should not be used in its original design while studying small and medium sized companies international establishment. Resting on the foundation of the original PSE model, the modified PSE model is introduced to particularly benefit studies of international market establishment among SMEs.

Thus, the research presented here is restricted to international establishment among SMEs. All empirical material will come from small and medium sized furniture producers in Sweden, a group of companies often described as conservative, operating within a mature industry. As the empirical data is collected from an industry resistant to change, but where competition is fierce, the theoretical applicability will be put to a tough test. Within the furniture industry only twelve percent of the firms have more than 30 employees, and the average firm has only four employees (Trä & Möbel Forum, 2008). Hence, the vast majority of the furniture producers in Sweden are small and medium sized.

Based on the above discussion and acknowledging that knowledge is missing on the complex issue of why some firms become internationally involved and why others continue serving only the domestic market, the research purpose is presented.

## Purpose

The purpose of this research is to *describe what differentiates small and medium sized Swedish furniture producers from each other considering their perceptions of internationalization barriers, entry strategies, strategy competences, and performance.*

## Theoretical Framework

The theoretical framework for this research rests on the PSE model, briefly described below. Thereafter the modified PSE model is introduced and presented in more detail, with particular emphasis on what is different compared to the preceding version.

### The original PSE model

The structure of the PSE model is in the shape of a tripod, allowing examination of the relationship to be found between how entry barriers are perceived (P), level of strategy competence (S) available within the firm,

[6] A firm entering an emerging market is faced with essentially the same obstacles and uncertainties as a firm entering a foreign market (Pehrsson, 2001). Therefore, entry into a foreign market and entry into an emerging market is here treated without distinction.

and what entry strategy (E) the firm selects for establishment into emergent markets. See *Figure 1* below for the original PSE model.

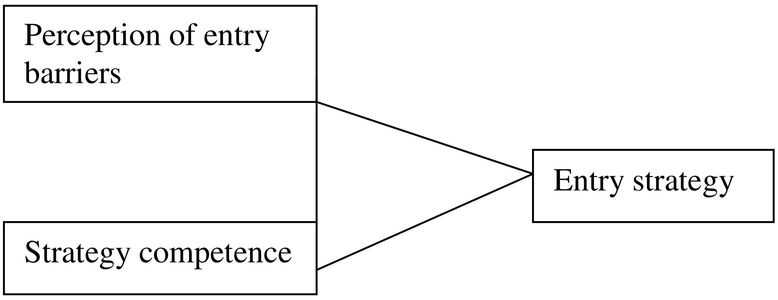


Figure Y: The original PSE model is an international market entry model consisting of three components as shown above (Pehrsson, 2001).

**The modified PSE model**

The modified PSE model is based exclusively on the original PSE model. However, because the original model was developed and applied around multinational corporations entering (emerging) markets, the need to questioning its relevance when used on exporting SMEs is apparent. For example, compared to large companies and corporations, smaller individual businesses operate with restricted access to financial, physical, human, technological, and organizational resources (Ekeledo and Sivakumar, 2004). Operating under strict resource constraints results in small margin of error (Wolff and Pett, 2006), which limit the firm's freedom of action with regards to, for example, market entry.

Below, each of the four components of the modified model is presented. Note that no attempts will be made to use the modified PSE model to study the internationalization *process* of the firms by capturing time effects.

**Perception of internationalization barriers**

A firm's internationalization is simultaneously influenced by, and therefore depends on, the following three factors; the firm's key decision maker; the internal organization; and the firm's external environment (Axinn and Matthyssens, 2002; Fillis, 2002; Leonidou, 1995). In the original PSE model, perception of entry barriers includes only factors external to the firm as defined by Porter. This is despite the fact that Pehrsson (2001) states that people within an organization influence how the firm perceives opportunities, and barriers. The modified model acknowledges that barriers to internationalization can stem from different sources. For clarity, the barrier component is therefore renamed from perception of entry barriers to *perception of internationalization barriers*.

Further, within the literature on entry barriers facing SMEs in their internationalization process, different authors group barriers differently. Leonidou (2000) discusses attitudinal; structural; procedural; and operational barriers, while Westhead et al (2004) use the following groupings: strategic; informational; process-based; and operational. In this research, barriers will be grouped into psychological; operational; product/market related; and organizational (Hamill, 1997).

*Psychological barriers* include perceptions of internationalization as being too expensive; too risky; not appropriate for the particular type of business; and not considered as a result of the domestic market being of satisfactory size. According to Hamill, *operational barriers* refer to hindrances related to the handling of export paperwork and documentation; lack of language skills; and delays in receiving payments. *Organizational barriers* include lack of resources to devote to export and lack of export experience. Finally, *product/market barriers* are factors caused by a misfit between what the firm has to offer and what the market demand. One example of a product/market barrier is the need for product adaptation.

**Strategy competence**

The strategy competence of a firm's management team is made up by the two sub-concepts of *relatedness* and *market experience*. The relatedness concept is not frequently used when discussing international establishment among SMEs. The main reason might be that relatedness commonly is used to discuss to what degree a firm's different business units align with the firm's core competence (Pehrsson, 2000). By definition, SMEs are restricted size-wise suggesting that they might not operate multiple business units. Thus, the relatedness aspect of SMEs' strategy competence cannot necessarily be determined based on a business unit's relatedness to the core competence of the firm. Instead it might be more appropriate to think of relatedness as how different firm functions or departments utilize resources and conduct activities that are similar to each other. This is in line with Farjoun's (1998) definition of relatedness as referred to relationships between activities or resources.

This research proposes that relatedness, as similarity between domestic and foreign activities and utilization of resources, is measured along the lines of pricing; general management skills; administrative skills; after-sales services; and brand recognition.

The market experience concept used in the PSE model will be adopted without any major changes. Thus, a firm's market experience will be subjectively measured by the firms' stated knowledge of or confidence with local competitors and local customers. The question is how much does a firm know about its competitors' product offers; customers; degrees of customization; pricing; and levels of research and development (R&D)?

How much a firm knows about its local customers will be evaluated in terms of customer types and locations. Higher confidence level will imply more market experience.

**Entry mode**

Market entry strategy decisions include entry mode selection for a particular target country and establishment of a marketing plan for the target market (Albaum et al. 2005). In accordance with existing research (Pehrsson, 2001), the inclusive term *entry strategy* will be substituted in the research model by the more specific term *entry mode*[7].

Because SMEs are known to have restricted access to resources, they typically enter foreign markets using a low resource demanding entry mode such as export (Lages and Montgomery, 2004). Benefits associated with export, as compared to other more advanced entry modes, include: low risks; low resource commitment; and high flexibility (Leonidou and Katsikeas, 1996). As a result, export is commonly considered an easy and attractive entry mode, particularly among SMEs (Morgan and Katsikeas, 1997). Considering these findings in light of the contextual setting of this study, the decision was made to restrict entry mode options for this study to different kinds of export. Export is here defined in terms of how products made in Sweden are sold in foreign countries through different direct and indirect sales channels.

Firms are believed to select entry modes, in a path-dependent fashion, in accordance with the stage theory. In a review of current empirical work of the export development process completed by Leonidou and Katsikeas (1996) resulted in the three-category classification of pre-engagement, initial, and advanced involvement.

In the *pre-engagement* category, firms are not involved in international business for one of three reasons. First, some SMEs, or rather their founders, may simply not have the ambition to grow beyond a certain size or market (European Commission, 2003). The key decision maker or management team might have reached the conclusion that internationalization does not fit the firm's type of business, and that the domestic market provides adequate demand now as well as in the future.

*"exporting may not always be the best growth strategy, especially if the firm can achieve positional competitive advantage in the domestic market"* (Leonidou and Katsikeas, 1996)

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[7] Sarkar and Cavusgil (1996) define international entry mode as "the institutional arrangement" (Sarkar and Cavusgil, 1996, pp. 826) that make it possible for a company to enter a market with its products and resources.

Second, some companies are interested in export even though they are not presently involved. One reason for why these firms are not involved includes the perception of internal and external entry barriers as being too high to bridge (European Commission, 2003). Third are the de-internationalized firms. These are companies that have been involved in international businesses but for some reason regressed to the pre-engagement phase.

In the *initial export* category, export is sporadic and is either increasing or decreasing. Firms answering unsolicited orders, thus reactive export behaviour (Riddle and Gillespie, 2003), belong for example to this first export phase (Leonidou, 2003). However, *indirect export* is the preferred entry mode for firms in this developmental phase. Indirect export is when a firm supplies a foreign market through an intermediary domestic partner (European Commission, 2003). For this study the indirect export modes included are export agents and piggyback[8]. General advantages associated with indirect export include: low costs; access to export professionals; speed of export volume accumulation; and low risk. The main disadvantages include lack of (end) customer contact; product goodwill is not ascribed the producer; and potential conflicts of interest between producer and intermediary (Albaum et al. 2005).

At the *advanced export* level we find the more experienced exporters involved in regular export activities. Firms conducting *direct export* are often found in this advanced state of development. When a company sells directly to a foreign importer or buyer, it is called *direct export*. Different sorts of direct export included in this study of exporting SMEs are: foreign sales branches (Leonidou and Katsikeas, 1996) including foreign resident salespeople; and traveling salespeople[9]. The benefits of these direct export modes include no profit sharing; full control; direct communication with foreign customers; permanent structure; product goodwill is granted the producer; and the possibility of attaining economy of scale. Further, foreign-based agents or distributors (Albaum et al. 2005) are also to be included as direct entry mode channels. Among all the different approaches to direct export, using exclusive agents or distributors is the easiest and less costly way (Ibid.). In general, direct export is believed to entail higher degree of management commitment; risks; and costs, than

[8] Piggyback is sometimes considered a mix between indirect and direct export (Albaum, 2005). However, for this study piggyback is considered indirect due to the domestic nature of the transactions.

[9] A travelling salesperson is based out of the producer's domestic market (Albaum et al. 2005). Holmlund and Kock (1998) found that one the most important entry modes among Finnish SMEs were to have their own salesmen. One advantage with sending their own salesman around to visit foreign customers included the direct contact established with customers and end-users.

indirect export. But while risks and costs are up, the direct exporter might be rewarded with higher return on investment.

Thus, this study will allow for separation between non-international firms, direct and indirect exporters. Consequently it will be possible to comment on how firms' choices of entry modes influence perception of barriers; strategy competence; and performance. However, working within the framework of the static PSE model, no attempts will be made to comment on whether different firms pursue different strategic approaches or if they have reached different levels of internationalization as part of an ongoing process.

**Performance**

Attempting to increase our knowledge about what factors influence firms' performance positively and negatively is logically of great interest to researchers, politicians, and not least practitioners. As a result, such research has received a great deal of research attention.

Also the individual components of the PSE model has been used in performance-searching research efforts. Perception of entry barriers and strategy competence have shown particular appropriateness (Pehrsson, 2004a; 2004b; 2006a; 2006b). But using performance as a dependent variable in simple research models is likely to fail as:

*"Performance feeds back upon itself through numerous mechanisms."* (March and Sutton, 1997, pp. 701)

Therefore the interest here is to determine the possibility of treating performance as more than just a dependent variable along with the other three interrelated components. What has been done within existing literature when it comes to using performance as independent variable?

During a literature review of journals in strategy and organizational behavior, March and Sutton (1997) found that almost a third of all articles included performance as a variable. They also discover that in 71% of these articles performance appeared as a dependent variable. In only 12% of the cases performance was included as an independent variable, and in the remaining 11% of the reviewed articles performance was treated as both an independent and dependent variable. From these findings it is clear that while performance has been used both as an independent and reciprocal variable, the frequency of this research approach is scant.

Further, in an empirical study of Portuguese SMEs, performance was included as an independent variable (Lages and Montgomery, 2004). The results from their study show that export performance is an antecedent of the firm's commitment to export and that export performance influence the firm's export strategy[10].

In line with most models of organizational learning, Lant et al. (1992) include firms' past performance as an explanatory variable of strategic change. Their findings show that a firm's past performance (poor or successful) has both a strong direct and indirect influence on the organization's strategic orientation. More precisely, successful past performance indirectly influence strategic change by having a positive significant effect on environmental awareness. This is supported by Wiersema and Bantel (1992) who conclude that a firm's part performance positively influences its strategic change in terms of diversification. In other words, a firm that demonstrates strong performance can assign resources for environmental scanning and analysis. Correspondingly, poor performance leads to reduced external information seeking.

Thus, existing research demonstrates that, while it is not the practice within the field of international strategy, treating performance as an independent variable can be worthwhile. Therefore, the idea is to incorporate performance into the frame of the model together with the other three interrelated components. The result would be a modified PSE model made up by four (possibly) reciprocal components, relating to each other depending on the contextual settings.

Finally, performance can be assessed by financial and non-financial measures and can be either objective or subjective (Pehrsson, 2004a; 2004b, 2002). Thirkell and Dau (1998) advocate that export performance should be measured using a multi-item performance scale including both objective and subjective measures. Here overall firm performance will be measured using the objective financial measurement of ROA, and the subjective financial measurement of satisfaction with overall performances as related to industry average.

## Research model

Based on the preceding theoretical discussions, the research model is established. This model is an outgrowth of the original PSE model to particularly benefit research of SMEs. For the model see *Figure 2* below. Evident in *Figure 2* and consistent with the original PSE model, no directional relationships of dependence are specified between the factors included in the model. Instead the strength and direction of existing relationships are likely to vary depending on firm specific attributes and is therefore a possible result of this study.

[10] Export performance was found to have significant indirect effect on product strategy adaptation; significant direct effect on pricing strategy adaptation; and significant direct and indirect effect on distribution strategy adaptation (Lages and Montgomery, 2004)

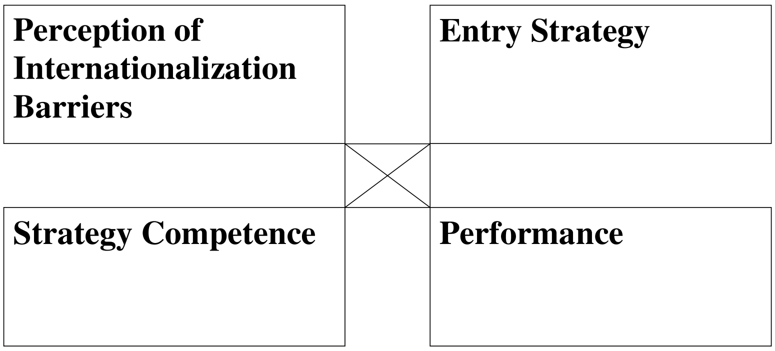

Figure 2: The modified international market entry model.

Further, based on the theoretical discussions of the original and modified PSE model, it is at this point possible to add more detail to the modified model. In *Figure 3* sub-components and other elements have been added, offering a research model with increased structural clarity.

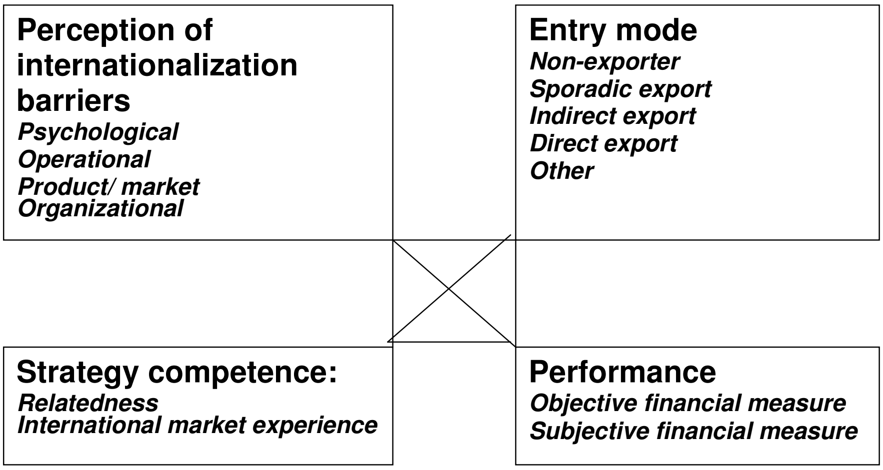

Figure 3: The detailed modified international market entry model includes sub-components and elements.

## Research design

In line with the purpose of the research, the relationships between the different components of the model are to be investigated. Therefore a number of hypotheses are constructed. Due to the fact that the hypotheses are not yet satisfactorily constructed, they are not included in this paper. The empirical data to be used for hypotheses testing will be collected using a quantitative survey addressed to the key decision makers or owners of the firms. All firms included in this study will initially be contacted by phone, whereby they are asked to participate in the study. The respondents will have the option to complete the survey over the phone, electronically using E-mail, or in written form (paper copy).

**Sample**

To be considered of interest for this research, all firms must be a SME and a furniture producer. The definition of SME used in this study is as defined by the European Commission, see footnote 1. In accordance with existing studies (European Commission, 2007), firms without employees will be excluded. Further, to control for sample heterogeneity, only furniture producers will be included in this study. Thus neither suppliers of parts and components nor retailers will be included. Approximately 420 companies in Sweden comply with the above definitions

**Discussion**

Theoretical contributions originating from this research are along the dimensions of perception of internationalization barriers (including barriers regardless of origin), different degrees of export involvement (ranging from non-exporters to highly involved direct exporters), definition of relatedness (define relatedness as degree of similarity between domestic and foreign business with regards to certain attributes), and adding performance as a forth component of the model. Each one of these theoretical contributions refers to the specifics that this research is focused on SMEs, and the existing PSE model had to be modified accordingly.

Further, being promising but still relatively new, the PSE model should benefit from being tested in a different contextual situation. It will be interesting to learn to what degree the PSE model can be used to explain behaviors among small and medium sized firms within one industry.

On a practical level, the aspiration is that this research should contribute to the furniture industry to some degree. At the lowest level, the study should provide a foundation for discussion among the industry members and a platform for insight among politicians and other interested parties. From a government perspective the study provides profiles of companies at varying degree of export engagement that can be used for designing export promotion programs. To ensure that the results of the study is efficiently communicated back to the practitioners and other interested parties, a brochure consisting of the main results will be distributed once the results are available.

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# Why Harwarders for Wood Harvesting?

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## Abstract

Currently, the total number of harwarders in industrial roundwood and energy wood harvesting in Finnish forests is slightly over one hundred. Metsäteho Oy conducted a follow-up study of harwarders in industrial roundwood harvesting in Finland, and also investigated the transfers of the harwarders. In the study of Metsäteho, the possibilities of harwarder systems in wood harvesting in the near future in Finland were also evaluated. It was forecasted that the number of harwarders will significantly increase in the near future in Finland; within a few years, the number of harwarders engaged in industrial roundwood and energy wood harvesting may even be as much as 200–300. This development forecast is based on the following factors: I) Cost effectiveness in wood harvesting is being sought at the level of the stand marked for harvesting, as well as from the point of view of the forest machine business. II) The structural change in cuttings is setting new demands on the harvesting machinery. III) As a result of changes in the forest machine business field, the size of forest machine contracting businesses is growing and large regional responsibilities in contracting are increasing.

**Keywords:** Harwarders, Wood harvesting systems, Cost-efficiency, Industrial roundwood, Finland.

## 1. Introduction

A harwarder is a forest machine that can be used for both cutting and forest haulage. The active development of harwarders in Finland started in the late 1990's after Lilleberg (1997) demonstrated that the harwarder was a more cost-effective wood harvesting system than a two-machine harvesting system consisting of a harvester and a forwarder, when the average industrial roundwood stem size in the marked stand was less than 150 $dm^3$. Since then, the productivity and profitability of harwarders in industrial roundwood harvesting, as well as in energy wood harvesting, have been investigated in many studies. However, these trials have been almost exclusively time studies. Comprehensive, long-term follow-up study data on harwarders have been produced in only two studies: Sirén and Aaltio (2003) in industrial roundwood harvesting, and Kärhä (2006) in energy wood harvesting.

In several studies (e.g. Strömgren 1999, Rieppo & Pekkola 2001, Bergkvist et al. 2003, Rieppo 2003, Sirén & Aaltio 2003, Emer 2005, Nordén et al. 2005, Kärhä 2006) the harwarder has proved to be a more cost-effective wood harvesting system than the traditional two-machine system, especially when the average stem size of the marked stand is relatively small, the removals per hectare/stand low, and the forwarding distance short.

One of the strengths of a harwarder is considered to be the lower transfer costs compared to the two-machine harvesting system. The distance, time consumption, and costs of harwarder transfers have not, however, been reported in the previous harwarder studies. A follow-up study of harwarders in industrial roundwood harvesting, as well as a study on the transfers of the harwarders, were carried out by Metsäteho Oy. In the study of Metsäteho, the possibilities of harwarder systems in wood harvesting in the near future in Finland were also evaluated.

## 2. Material and methods

### 2.1. Follow-up study

A total of five harwarders – three Ponsse Wisent Duals (also in this article *Ponsse Dual*) and two Valmet 801 Combis (also *Valmet Combi*) – were covered in the follow-up study. Eleven different harwarder operators participated in the follow-up study. The follow-up period started in September 2004, and continued until May 2005. The follow-up data were collected by Telmu 100 dataloggers. The harvesting conditions were obtained from the wood procurement organizations for which each harwarder was contracted. The total industrial roundwood harvested with the Ponsse Dual harwarders was almost 25,000 $m^3$. The study material with the Valmet Combi harwarders was smaller, only around 5,000 $m^3$. The amount of harvested industrial roundwood in the follow-up study totalled nearly 30,000 $m^3$.

The number of harvesting sites totalled 92, and data about the harvesting conditions were obtained from 70 of the sites. The harwarders were primarily used in thinnings in the follow-up study: 14% of the total volume of industrial roundwood harvested came from first thinnings, and 43% from later thinnings. Less than one-third of the wood quantity came from final cuttings. The proportion of other/combined cuttings was 11%. Furthermore, harwarders were used principally for real harwarder work, i.e. both cutting and forwarding were done by a harwarder at the harvesting site (Fig. 1). Harwarders were also used to balance two-machine (harvester–forwarder) harvesting systems, with the cutting carried out by a harwarder and the forwarding performed later on by a forwarder. There were only a few harvesting sites where the harwarders carried out only forest haulage at the harvesting site (Fig. 1).

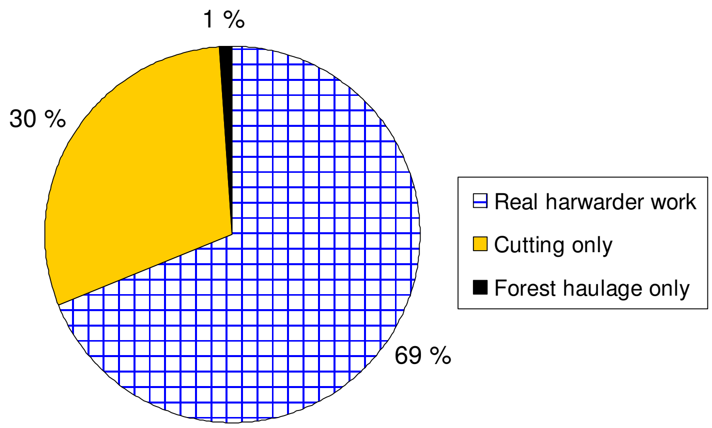


**Figure 1.** Proportion of different modes of operation out of the total volume of industrial roundwood harvested by harwarders in the follow-up study. Real harwarder work consists of both cutting and forwarding with a harwarder at the harvesting site.

The cutting was initially mainly performed by the Ponsse Dual harwarders included in the follow-up study and, after that, the machines were outfitted for forwarding and used to haul the felled timber to the roadside. In thinnings with the Valmet Combi harwarders, the following working method was mainly applied. The harwarder was driven forward into the stand while, at the same time, the trees along the strip road were cut and both sides of the strip road were thinned. The felled timber was bunched mainly into piles along the strip road. At the end of the strip road the harwarder was turned around and driven back along the harvested strip road while, at the same time, the bunched stems were loaded. In final cuttings, the Valmet Combi harwarders were driven forward parallel with the edge of the stand while cutting along one side. Direct loading was not carried out with the Valmet Combi harwarders in the follow-up study in either final cuttings or thinnings.

### 2.2. Studies on transfers

The research data on transfers with harwarders were collected by interviewing 13 harwarder entrepreneurs, in addition to conducting time studies on two harwarder transfers. The interviews were conducted during April 2003, and the time studies were carried out in October 2003 and

January 2004. Research data on harwarder transfers were also collated from the follow-up study on harwarders.

### 2.3. Cost calculations and system analysis

Cost calculations were prepared for two harwarders, of which the purchase price of the Harwarder II was 100,000 € (VAT 0%) higher than that of Harwarder I, and for the two-machine harvesting system which consisted of a harvester for thinnings (weight: 13–15 tons; e.g. John Deere 1070D, Ponsse Beaver, Valmet 901) and a medium-duty forwarder (carrying capacity: 10–12 tons; e.g. John Deere 1110D, Ponsse Wisent, Valmet 840) (Table 1). For all the machines, the annual operating hours were standardized as 2,574 $E_{15}$-hours in the calculations. In the cost calculations, the proportion of thinnings was 40% of the total volume of roundwood harvested. The operating hour costs for the harvester for thinnings were 79 €/$E_{15}$-hour and for the medium-duty forwarder 57 €/$E_{15}$-hour (Table 1). The operating hour costs of the Harwarder I were 73 €/$E_{15}$-hour and of the Harwarder II 82 €/$E_{15}$-hour.

**Table 1.** The purchase prices, operating hour productivities and annual outputs used in the cost calculations, as well as the calculated operating hour costs of the machines.

| Machine | Purchase price, € (VAT 0%) | Productivity, $m^3/E_{15}$-hour | | Industrial roundwood, $m^3/a$ | Operating hour costs, €/$E_{15}$-hour |
|---|---|---|---|---|---|
| | | Thinnings | Final cuttings | | |
| Harwarder | | | | | |
| - I | 288,000 | 6.1 | 7.7 | 17,939 | 73 |
| - II | 388,000 | 6.1 | 7.7 | 17,939 | 82 |
| Harvesting system | | | | | |
| - harvester | 279,000 | 8.5 | 18.0 | 32,015 | 79 |
| - forwarder | 187,000 | 11.0 | 15.0 | 33,657 | 57 |

The wood harvesting costs in thinnings with Harwarders I and II were compared to the harvesting costs with the two-machine harvesting system. The effective ($E_0$) hour productivities in thinnings with the two-machine harvesting system in cutting and forest haulage were determined by the time consumption models presented by Kärhä et al. (2006). It was assumed that, when the average stem size in the stand increased from 50 $dm^3$ to 250 $dm^3$, the roundwood removal increased from 36 $m^3$/ha to 81 $m^3$/ha (cf. Kärhä 2007). There were 500 Norway spruce (*Picea abies* L. Karst.) undergrowth trees per hectare in the thinning stand, and the average height of the spruce undergrowth trees was 2 m. The average load size was 11.0 $m^3$ in forest haulage with a forwarder.

## 3. Results

In the follow-up study, the technical utilization rate was 88.1% on the average, and the operational utilization rate was 82.6%. In real harwarder work, based on the entire follow-up study material (average stem size in marked stand 198 $dm^3$ and average forest haulage distance 239 m), on the average 57% of the effective working time was used for cutting and 43% for forest haulage (Fig. 2). With first thinnings (89 $dm^3$ and 280 m), the cutting took on the average 63% and forwarding 37% of the effective working time. With final cuttings (326 $dm^3$ and 179 m), the effective working time was split almost equally between cutting and forest haulage (Fig. 2).

In real harwarder work within the follow-up study, the productivity per operating hour in first thinnings was, on the average, 5.1 $m^3/E_{15}$-hour and in other thinnings 6.4 $m^3/E_{15}$-hour. In the case of thinnings, the productivity per operating hour of real harwarder work was best explained by the average stem size in the marked stand (Fig. 3). The forest haulage distance also had an impact on the operating hour productivity. In the final cutting of the real harwarder work within the follow-up study, the average productivity was 7.7 $m^3/E_{15}$-hour.

The harwarder systems were more competitive than the two-machine system when the average stem size of the marked stand was relatively low, i.e. less than 120–180 $dm^3$ (Fig. 4). In this case, the industrial roundwood removal is below 60–70 $m^3$/ha (cf. Kärhä 2007). Furthermore, harwarders were the most competitive in low-removal stands, particularly at harvesting sites that were below 50 $m^3$. As the stem size in stand and roundwood removal per hectare/stand increased, the competitiveness of the two-machine harvesting system improved in comparison to that of the harwarder systems (Fig. 4).

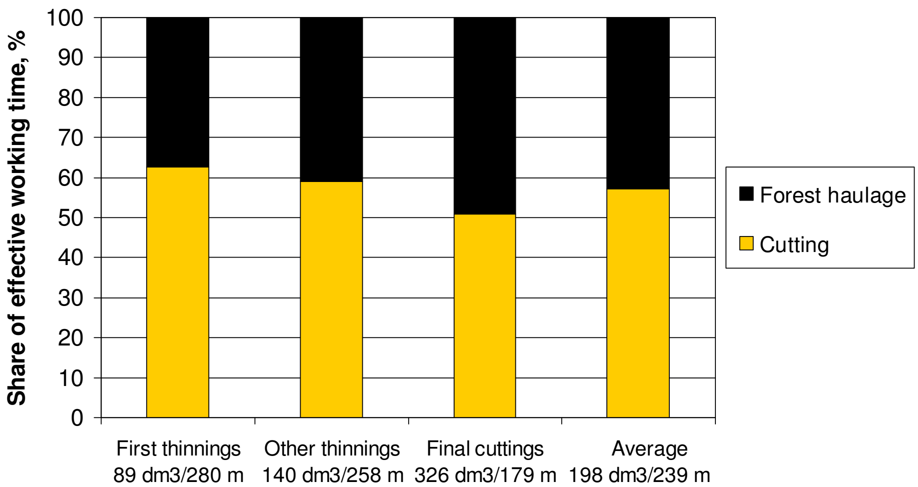

**Figure 2.** Distribution of the effective working time in real harwarder work by cutting method, and on the average in the follow-up study. The average stem size of the marked stand and average forwarding distance at sites for which the data of harvesting conditions were available are also shown.

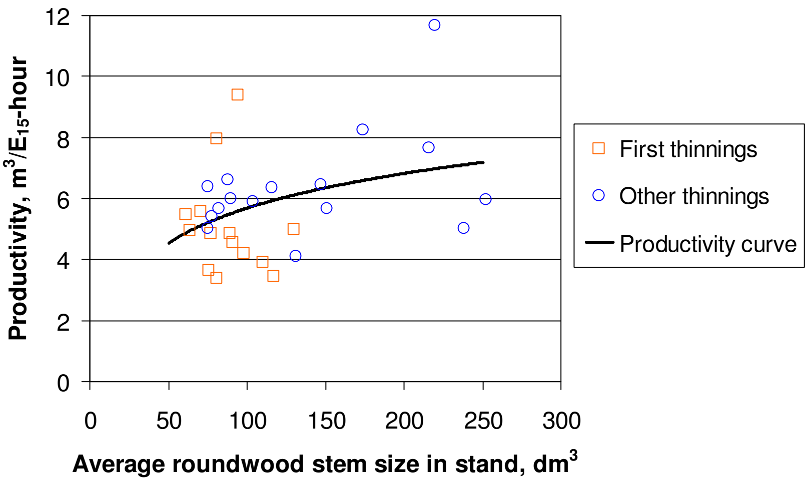


**Figure 3.** Operating ($E_{15}$) hour productivity in thinnings in real harwarder work by harvesting site, and the productivity curve as a function of average stem size.

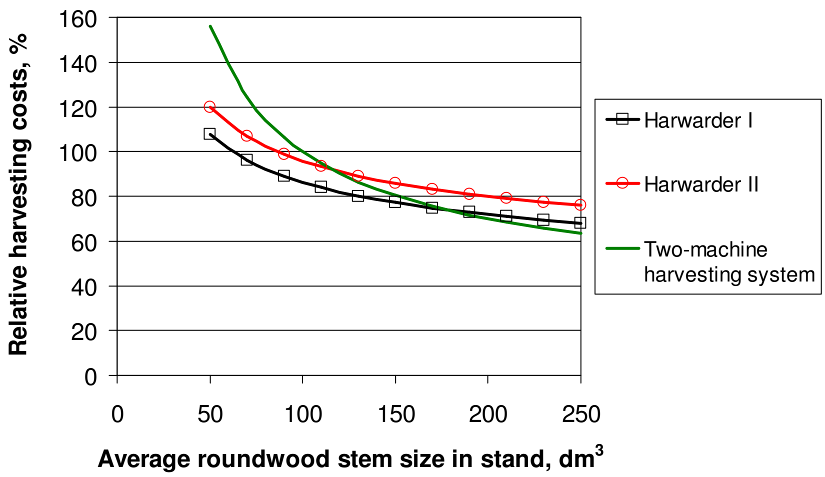


**Figure 4.** Effect of average stem size on the relative harvesting costs of thinning wood with Harwarders I and II and with a two-machine harvesting system. The purchase price of Harwarder II was 100,000 € (VAT 0%) higher than of Harwarder I. Industrial roundwood removal increased from 36 $m^3$/ha (average stem size 50 $dm^3$) to 81 $m^3$/ha (250 $dm^3$), and the

forwarding distance was 250 m. Harvesting costs 100 = Harvesting costs with a two-machine harvesting system at an average stem size of 100 $dm^3$.

In the follow-up study, the proportion of the total work-time of harwarders used in transfers between harvesting sites was 2.5%, and the effective transfer time was, on the average, 1.3 hours/transfer (Fig. 5). The harwarder entrepreneurs interviewed calculated that the transfer distance with a harwarder from one stand to another is, on the average, 28 km. The study showed that, in addition to the primary harwarder transfer, a lot of time is spent in both the preparatory work phases prior to the transfer (e.g. transmitting cutting and forwarding data, cleaning the harwarder, driving the harwarder onto the transfer truck, binding the harwarder) and the finishing work phases of the transfer.

The average transfer costs of the harwarder, according to the estimates of the entrepreneurs interviewed, were 203 €. The average transfer costs of a two-machine harvesting system were 469 €/transfer/harvesting system. On the basis of these figures, the transfer costs of a harwarder were less than half (43%) those of a two-machine harvesting system.

## 4. Discussion and conclusions

Currently, the total number of harwarders in use in Finnish forests is slightly over one hundred, of which more than half are mainly engaged in industrial roundwood harvesting and the remainder in energy wood harvesting. Harwarders have not been as widely adopted as would be expected in the light of the positive results of harwarder studies.

The reasons for the relatively slow growth in harwarder usage have not been documented. Possible reasons include resistance and prejudice towards harwarders, together with entrenched preferences for traditional harvesting technology. These factors came to light in Metsäteho's investigation on the increasing use of tracked excavators in harvesting operations in Finland (Bergroth et al. 2007).

The number of harwarders will undoubtedly significantly increase in the near future in Finland; within a few years, the number of harwarders engaged in industrial roundwood and energy wood harvesting may even be as much as 200–300. This development forecast is based on the following factors:

1) *Cost effectiveness in wood harvesting is being sought at the level of the stand marked for harvesting, as well as from the point of view of the forest machine business*. A harwarder has a clear competitive advantage in small-removal thinnings and final cuttings, forest fellings in the archipelago, the harvesting of wind-felled trees, and in seed tree and shelterwood fellings (Kärhä et al. 2001). It makes sense to harvest

relatively small-removal and small-diameter stands marked for harvesting with a harwarder while, conversely, it is more worthwhile to harvest sites with larger removals and trees using a two-machine harvesting system, thereby raising the profitability of two-machine harvesting systems.

A forest machine contractor's reserve of stands marked for cutting essentially determines how optimally a harwarder can be used. The larger the stand reserve volume the forest machine contractor has, the better are the opportunities to effectively utilize his forest machine stock (Jylhä et al. 2006).

2) *The structural change in cuttings is setting new demands on the harvesting machinery*. Wood harvesting volumes of thinnings and on peatlands will grow during the next ten years (Nuutinen et al. 2000, Nuutinen & Hirvelä 2006). The harvesting conditions described above (small stem size and low removals) are ideally suited for harwarder.

   The use of harwarders also means less driving is needed during harvesting operations, thus minimising strip road rutting. In peatland harvesting, however, long forwarding distances may reduce the profitability of harvesting based on a harwarder.

3) *As a result of changes in the forest machine business field, the size of forest machine contracting businesses is growing and large regional responsibilities in contracting are increasing*. These changes are creating a potential for the use of specialized harvesting machinery. In this respect, the acquisition of a harwarder alongside two-machine harvesting systems may be a sensible alternative.

When evaluating the competitiveness of harwarders, the relatively short development track of harwarders must be kept in mind. Harwarders have been actively developed for only about ten years. By developing harwarders and their working methods and organization, it will be possible to further improve the competitiveness of harwarders.

One potential development trend is the additional versatility of harwarders, whereby the same base machine is used to carry out several different types of work, up to 3–4 different tasks, on each return to site (cf. Kärhä & Peltola 2004). Possible work type combinations include, for example, different silvicultural tasks, forest regeneration, and industrial roundwood and energy wood harvesting. The large number of different work tasks is not, however, in itself the primary objective; rather the aim of versatility is to offer a means of improving operational profitability.

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# Impact of Thinning Intensity on the Harvesting Costs of First-Thinning Wood in Scots pine Stands

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## Abstract

In the new forest management recommendations in Finland, one cultivation alternative for Scots pine (*Pinus sylvestris* L.) is intensive cultivation in which the quality of a poor or mediocre pine stand is improved by carrying out an intensive, quality first thinning. This type of thinning leaves ca. 700 trees per hectare. The research conducted by Metsäteho Oy investigated how harvesting conditions and costs change when the thinning intensity is increased and intensive, quality thinning is carried out in first-thinning Scots pine stands. The study showed that the harvesting conditions in intensive, quality thinning are superior, resulting in lower harvesting costs than for normal first thinning. One item of particular note was the drop in cutting costs. Intensive, quality thinning had less of an impact on the forest haulage costs. The reduction in harvesting costs, and especially in the cutting costs, was dependent on the extent to which the average stem size of the trees to be harvested increased throughout the marked stand. When the average stem size of the trees to be harvested increased by 25%, the harvesting costs in the typical harvesting conditions of first-thinning pine stands were 15–19% lower than in normal first thinning.

**Keywords:** Thinning intensity, Industrial roundwood, Pulpwood, First thinnings, Scots pine, Wood harvesting, Costs.

## 1. Introduction

During the 1970's and the beginning of the 1980's, the artificial regeneration area for Scots pine (*Pinus sylvestris* L.) in Finland annually totalled over 100,000 hectares, of which over two-thirds consisted of planting (Juntunen & Herrala-Ylinen 2007). Part of the area planted with pine included excessively fertile sites, resulting in poor quality, thick-branched pine stands. It is estimated that there are more than 0.5 million hectares of poor-quality Scots pine stands in Finland.

In the new forest management recommendations drawn up by Forestry Development Centre Tapio (Anon. 2006), one cultivation alternative for Scots pine is intensive cultivation in which the quality of a poor or mediocre pine stand is improved by carrying out an intensive, quality first thinning. This type of thinning leaves ca. 700 trees per hectare, whereas a normal first thinning leaves 900–1,000 trees per hectare (Anon. 2006). The research conducted by Metsäteho Oy investigated how harvesting conditions and costs change when the thinning intensity is increased and intensive, quality thinning is carried out in first-thinning Scots pine stands.

## 2. Material and methods

The impact of undergrowth on the productivity of harvesting work in first-thinning stands was clarified in the study conducted by Kärhä (2006). The thinning intensity (the removal density as a proportion of the initial growing stock density) in the study by Kärhä (2006) was relatively high, 51% on the average. The time consumption functions for industrial roundwood (i.e. pulpwood) cutting and forest haulage developed by Kärhä et al. (2006) were applied in the cost calculations of this research. It was assumed that there were 1,000 Norway spruce (*Picea abies* (L.) Karst.) undergrowth trees per hectare in a Scots pine first-thinning stand, and the average height of the spruce undergrowth trees was 2 m.

When calculating the wood harvesting costs, it was assumed that the removal density in an intensive, quality thinning is 250 industrial roundwood trees/ha greater than in a normal first thinning (Table 1). When the density of removal was very high (>1,600 roundwood trees/ha), the harvesting costs for this kind of site were not calculated in the research. Three different alternatives were developed for the cost comparisons between a intensive, quality thinning and a normal first thinning. The alternatives were:

1) Stem size of the trees to be harvested did not increase,
2) Stem size of the trees to be harvested increased by 25%, and
3) Stem size of the trees to be harvested increased by 50%.

When drawing up the cost calculations, it was assumed that cutting is carried out by a harvester for thinnings (weight: 13–15 tons) and forest haulage with a medium-duty forwarder (carrying capacity: 10–12 tons). The operating hour costs for the harvester were 79 €/$E_{15}$-hour, and for the forwarder 55 €/$E_{15}$-hour. The pulpwood load size in forest haulage was 10.0 $m^3$ in the calculations.

**Table 1.** Removal matrix used in the calculations for normal first thinning. In an intensive, quality thinning, the density of removal was 250 industrial roundwood trees/ha greater than in a normal first thinning.

| Stem size, dm³ | Industrial roundwood removal, m³/ha | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| | Density of removal, trees/ha | | | | | | | | |
| 40 | 500 | 750 | 1,000 | 1,250 | | | | | |
| 50 | 400 | 600 | 800 | 1,000 | 1,200 | | | | |
| 60 | 333 | 500 | 667 | 833 | 1,000 | 1,167 | 1,333 | | |
| 70 | 286 | 429 | 571 | 714 | 857 | 1,000 | 1,143 | 1,286 | |
| 80 | 250 | 375 | 500 | 625 | 750 | 875 | 1,000 | 1,125 | 1,250 |
| 90 | 222 | 333 | 444 | 556 | 667 | 778 | 889 | 1,000 | 1,111 |
| 100 | 200 | 300 | 400 | 500 | 600 | 700 | 800 | 900 | 1,000 |
| 110 | 182 | 273 | 364 | 455 | 545 | 636 | 727 | 818 | 909 |
| 120 | 167 | 250 | 333 | 417 | 500 | 583 | 667 | 750 | 833 |
| 130 | 154 | 231 | 308 | 385 | 462 | 538 | 615 | 692 | 769 |
| 140 | 143 | 214 | 286 | 357 | 429 | 500 | 571 | 643 | 714 |

**Figure 1.** Scots pine first-thinning stand after an intensive, quality thinning. There are 650 trees remaining per hectare in the stand. Photo: Metsäteho Oy / Kalle Kärhä.

# 3. Results

## 3.1. Harvesting conditions

When 250 trees per hectare more than in normal first thinning were harvested in a first-thinning Scots pine stand in intensive, quality thinning in typical harvesting conditions (i.e. stem size: 50–100 $dm^3$ and industrial roundwood removal: 20–60 $m^3$/ha (cf. Kärhä 2007)), the thinning intensity increased by 13–21 %-units. The increased removal density increased, in turn, the industrial roundwood removal of the marked first-thinning stand.

When the average stem size of the trees harvested in intensive, quality thinning was not increased, the industrial roundwood removal was 13–25 $m^3$/ha higher than in normal first thinning of a Scots pine stand in typical harvesting conditions (Table 2).

When the average stem size of the harvested trees was raised in an intensive, quality thinning, the industrial roundwood removal increased significantly compared to that in normal first thinning (Table 2). When the average harvested stem size was raised by 25%, the removal increased by 21–44 $m^3$/ha in typical harvesting conditions. When the average harvested stem size was increased by 50%, the removal increased by 29–64 $m^3$/ha compared to normal first thinning.

### 3.2. Harvesting costs

An increase in the average stem size of the trees harvested in intensive, quality thinning had a significant impact on the productivity and costs of cutting work. When the average stem size of the trees harvested in intensive, quality thinning was not raised, the cutting costs were 2–7% (0.4–1.0 €/$m^3$) lower than in normal first thinning in typical harvesting conditions. The relative forest haulage cost savings were similar to those of cutting. The overall harvesting costs were 0.5–1.5 €/$m^3$ lower than in normal first thinning in typical harvesting conditions in a Scots pine stand (Table 3).

When the average stem size was increased by one quarter, the cutting costs were over 20% (2.2–4.7 €/$m^3$) lower than in normal first thinning in typical harvesting conditions. The smaller the average stem size of the harvested first-thinning stand, the higher were the cost savings for cutting. The effect of average harvested stem size on the forest haulage costs was lower than the effect on the cutting costs. When the average stem size of the harvested trees was raised by 25%, the harvesting costs fell by 15–19% (2.6–5.3 €/$m^3$) compared to normal first thinning in typical harvesting conditions (Table 3).

When the average harvested stem size was raised by 50%, the cutting costs were more than 30% (3.4–7.0 €/$m^3$) lower and the forest haulage costs 6–12% (0.4–0.9 €/$m^3$) lower than in normal first thinning. The overall harvesting costs were 23–28% (3.9–7.7 €/$m^3$) lower than in normal first thinning in typical harvesting conditions in a pine stand (Table 3).

**Table 2.** Industrial roundwood removal matrices for three alternatives used in intensive, quality thinning: 1) Stem size of the trees to be harvested did not increase, 2) Stem size of the trees to be harvested increased by 25%, and 3) Stem size of the trees to be harvested increased by 50%. The table also gives the stem size and industrial roundwood removal in normal (N; light grey) first thinning.

*1) Stem size of the trees to be harvested did not increase.*

| 1 | N | Industrial roundwood removal, $m^3$/ha | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Stem size, $dm^3$ | | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| 40 | 40 | 30 | 40 | 50 | 60 | | | | | |
| 50 | 50 | 33 | 43 | 53 | 63 | 73 | | | | |
| 60 | 60 | 35 | 45 | 55 | 65 | 75 | 85 | 95 | | |
| 70 | 70 | 38 | 48 | 58 | 68 | 78 | 88 | 98 | 108 | |
| 80 | 80 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 110 | 120 |
| 90 | 90 | 43 | 53 | 63 | 73 | 83 | 93 | 103 | 113 | 123 |
| 100 | 100 | 45 | 55 | 65 | 75 | 85 | 95 | 105 | 115 | 125 |
| 110 | 110 | 48 | 58 | 68 | 78 | 88 | 98 | 108 | 118 | 128 |
| 120 | 120 | 50 | 60 | 70 | 80 | 90 | 100 | 110 | 120 | 130 |
| 130 | 130 | 53 | 63 | 73 | 83 | 93 | 103 | 113 | 123 | 133 |
| 140 | 140 | 55 | 65 | 75 | 85 | 95 | 105 | 115 | 125 | 135 |

*2) Stem size of the trees to be harvested increased by 25%.*

| 2 | N | Industrial roundwood removal, $m^3$/ha | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Stem size, $dm^3$ | | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| 50 | 40 | 38 | 50 | 63 | 75 | | | | | |
| 63 | 50 | 41 | 53 | 66 | 78 | 91 | | | | |
| 75 | 60 | 44 | 56 | 69 | 81 | 94 | 106 | 119 | | |
| 88 | 70 | 47 | 59 | 72 | 84 | 97 | 109 | 122 | 134 | |
| 100 | 80 | 50 | 63 | 75 | 88 | 100 | 113 | 125 | 138 | 150 |
| 113 | 90 | 53 | 66 | 78 | 91 | 103 | 116 | 128 | 141 | 153 |
| 125 | 100 | 56 | 69 | 81 | 94 | 106 | 119 | 131 | 144 | 156 |
| 138 | 110 | 59 | 72 | 84 | 97 | 109 | 122 | 134 | 147 | 159 |
| 150 | 120 | 63 | 75 | 88 | 100 | 113 | 125 | 138 | 150 | 163 |
| 163 | 130 | 66 | 78 | 91 | 103 | 116 | 128 | 141 | 153 | 166 |
| 175 | 140 | 69 | 81 | 94 | 106 | 119 | 131 | 144 | 156 | 169 |

*3) Stem size of the trees to be harvested increased by 50%.*

| 3 | N | Industrial roundwood removal, $m^3$/ha | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Stem size, $dm^3$ | | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| 60 | 40 | 45 | 60 | 75 | 90 | | | | | |
| 75 | 50 | 49 | 64 | 79 | 94 | 109 | | | | |
| 90 | 60 | 53 | 68 | 83 | 98 | 113 | 128 | 143 | | |
| 105 | 70 | 56 | 71 | 86 | 101 | 116 | 131 | 146 | 161 | |
| 120 | 80 | 60 | 75 | 90 | 105 | 120 | 135 | 150 | 165 | 180 |
| 135 | 90 | 64 | 79 | 94 | 109 | 124 | 139 | 154 | 169 | 184 |
| 150 | 100 | 68 | 83 | 98 | 113 | 128 | 143 | 158 | 173 | 188 |
| 165 | 110 | 71 | 86 | 101 | 116 | 131 | 146 | 161 | 176 | 191 |
| 180 | 120 | 75 | 90 | 105 | 120 | 135 | 150 | 165 | 180 | 195 |
| 195 | 130 | 79 | 94 | 109 | 124 | 139 | 154 | 169 | 184 | 199 |
| 210 | 140 | 83 | 98 | 113 | 128 | 143 | 158 | 173 | 188 | 203 |

**Table 3.** Reduction in Scots pine first-thi nning harvesting costs for three alternatives used in an intensive, quality thinning compared to a normal (N) first thinning: *1) Stem size of the trees to be harvested did not increase, 2) Stem size of the trees to be harvested increased by 25%, and 3) Stem size of the trees to be harvested increased by 50%.*

*1) Stem size of the trees to be harvested did not increase.*

| | | Industrial roundwood removal, m$^3$/ha | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 30–55 | 40–65 | 50–75 | 60–85 | 73–95 | 85–105 | 95–115 | 108–125 | 120–135 |
| 1 | N | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| Stem size, dm$^3$ | | Savings in harvesting costs, €/m$^3$ | | | | | | | | |
| 40 | 40 | 1.4 | 1.0 | 0.7 | 0.6 | | | | | |
| 50 | 50 | 1.4 | 1.0 | 0.8 | 0.6 | 0.5 | | | | |
| 60 | 60 | 1.4 | 1.0 | 0.8 | 0.6 | 0.5 | 0.5 | 0.4 | | |
| 70 | 70 | 1.4 | 1.0 | 0.8 | 0.7 | 0.6 | 0.5 | 0.4 | 0.4 | |
| 80 | 80 | 1.4 | 1.0 | 0.8 | 0.7 | 0.6 | 0.5 | 0.4 | 0.4 | 0.3 |
| 90 | 90 | 1.5 | 1.1 | 0.8 | 0.7 | 0.6 | 0.5 | 0.4 | 0.4 | 0.4 |
| 100 | 100 | 1.5 | 1.1 | 0.8 | 0.7 | 0.6 | 0.5 | 0.4 | 0.4 | 0.4 |
| 110 | 110 | 1.5 | 1.1 | 0.9 | 0.7 | 0.6 | 0.5 | 0.5 | 0.4 | 0.4 |
| 120 | 120 | 1.5 | 1.1 | 0.9 | 0.7 | 0.6 | 0.5 | 0.5 | 0.4 | 0.4 |
| 130 | 130 | 1.5 | 1.1 | 0.9 | 0.7 | 0.6 | 0.5 | 0.5 | 0.4 | 0.4 |
| 140 | 140 | 1.5 | 1.1 | 0.9 | 0.7 | 0.6 | 0.5 | 0.5 | 0.4 | 0.4 |

*2) Stem size of the trees to be harvested increased by 25%.*

| **1** | | Industrial roundwood removal, m$^3$/ha | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 38–69 | 50–81 | 63–94 | 75–106 | 91–119 | 106–131 | 119–144 | 134–156 | 150–169 |
| | N | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| Stem size, dm$^3$ | | Savings in harvesting costs, €/m$^3$ | | | | | | | | |
| 50 | 40 | 6.0 | 5.4 | 5.1 | 4.8 | | | | | |
| 63 | 50 | 5.3 | 4.7 | 4.4 | 4.2 | 4.0 | | | | |
| 75 | 60 | 4.6 | 4.1 | 3.8 | 3.6 | 3.5 | 3.3 | 3.2 | | |
| 88 | 70 | 4.3 | 3.8 | 3.5 | 3.3 | 3.2 | 3.0 | 3.0 | 2.9 | |
| 100 | 80 | 3.9 | 3.4 | 3.2 | 3.0 | 2.9 | 2.7 | 2.7 | 2.6 | 2.5 |
| 113 | 90 | 3.7 | 3.3 | 3.0 | 2.8 | 2.7 | 2.6 | 2.5 | 2.4 | 2.4 |
| 125 | 100 | 3.5 | 3.1 | 2.8 | 2.6 | 2.5 | 2.4 | 2.3 | 2.2 | 2.2 |
| 138 | 110 | 3.4 | 2.9 | 2.7 | 2.5 | 2.4 | 2.3 | 2.2 | 2.1 | 2.1 |
| 150 | 120 | 3.2 | 2.8 | 2.5 | 2.4 | 2.2 | 2.1 | 2.1 | 2.0 | 1.9 |
| 163 | 130 | 3.1 | 2.7 | 2.5 | 2.3 | 2.2 | 2.1 | 2.0 | 1.9 | 1.9 |
| 175 | 140 | 3.0 | 2.6 | 2.4 | 2.2 | 2.1 | 2.0 | 1.9 | 1.8 | 1.8 |

*3) Stem size of the trees to be harvested increased by 50%.*

| | | Industrial roundwood removal, m$^3$/ha | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 45–83 | 60–98 | 75–113 | 90–128 | 109–143 | 128–158 | 143–173 | 161–188 | 180–203 |
| 3 | N | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| Stem size, dm$^3$ | | Savings in harvesting costs, €/m$^3$ | | | | | | | | |
| 60 | 40 | 9.0 | 8.4 | 7.9 | 7.6 | | | | | |
| 75 | 50 | 7.7 | 7.1 | 6.7 | 6.4 | 6.2 | | | | |
| 90 | 60 | 6.8 | 6.2 | 5.9 | 5.6 | 5.4 | 5.3 | 5.2 | | |
| 105 | 70 | 6.1 | 5.6 | 5.2 | 5.0 | 4.8 | 4.7 | 4.6 | 4.5 | |
| 120 | 80 | 5.6 | 5.1 | 4.8 | 4.6 | 4.4 | 4.3 | 4.2 | 4.1 | 4.0 |
| 135 | 90 | 5.2 | 4.7 | 4.4 | 4.2 | 4.1 | 3.9 | 3.8 | 3.8 | 3.7 |
| 150 | 100 | 4.9 | 4.4 | 4.1 | 3.9 | 3.8 | 3.7 | 3.6 | 3.5 | 3.4 |
| 165 | 110 | 4.6 | 4.2 | 3.9 | 3.7 | 3.6 | 3.4 | 3.3 | 3.3 | 3.2 |
| 180 | 120 | 4.4 | 4.0 | 3.7 | 3.5 | 3.4 | 3.3 | 3.2 | 3.1 | 3.0 |
| 195 | 130 | 4.2 | 3.8 | 3.5 | 3.3 | 3.2 | 3.1 | 3.0 | 2.9 | 2.9 |
| 210 | 140 | 4.1 | 3.7 | 3.4 | 3.2 | 3.1 | 3.0 | 2.9 | 2.8 | 2.7 |

## 4. Discussion and conclusions

In terms of stumpage earnings and forestry profitability, it is essential to produce sawlogs in Scots pine cultivation. Intensive silvicultural treatments are applied in poor and mediocre Scots pine stands in order to achieve the best possible yields from the poorly growing trees. The main objective is to produce large-diameter, knot-free butt logs using a stand treatment programme that includes pruning, as well as intensive, quality thinning at a dominant stand height of 10–12 metres (Anon. 2006).

Instead of the standard three thinning operations, the intensive cultivation model employs just two thinnings (Anon. 2006). Due to the intensive first thinning and wider spacing, the trees have thicker growth rings. However, this has no known detrimental effect on the strength properties of the sawn timber.

According to the new national forest management recommendations, intensive cultivation should only be applied in the treatment of poor and mediocre quality Scots pine stands on moist or moderately dry upland forest sites in southern and central Finland (Anon. 2006). Intensive cultivation is not a general treatment alternative for all Scots pine stands. Nor is it always suitable, because intensive first thinning has been observed to cause considerable growth losses in Scots pine stands during the 10-year period following thinning, if fertilization is not carried out (e.g. Vuokila 1981, Mäkinen & Isomäki 2004). Growth losses are eliminated if fertilization is carried out a few years after the first thinning (Mäkinen et al. 2005).

Growth losses are compensated by the decrease in the rotation period, the transfer of growth to more valuable sawn wood, the smaller risk of harvesting damage, and the lower harvesting costs (cf. Mäkinen & Isomäki 2004, Mäkinen et al. 2005). The study showed that the harvesting conditions in intensive, quality thinning are superior, resulting in lower harvesting costs than for normal first thinning. One item of particular interest was the decrease in the cutting costs. Intensive, quality thinning has less of an impact on the forest haulage costs.

The reduction in harvesting costs, and especially in the cutting costs, is related to how much the average stem size of the trees to be harvested increases throughout the marked stand. The extent to which the average stem size harvested is increased in intensive, quality thinning depends on the spatial distribution and structure of the first-thinning stand. It can be assumed, however, that the average stem size harvested in intensive, quality thinning will be higher than that in normal first thinning.

When the average stem size of the trees to be harvested increased by 25%, which is a relatively realistic increase in the stem size harvested in the stand, the harvesting costs around 3 €/m$^3$ lower than in normal first thinning in the typical harvesting conditions in Scots pine stand in Finland. The cost savings were significant: in 2005, the average harvesting costs in mechanized pine first thinnings were 15.5 €/m$^3$ (cutting: 11.1 €/m$^3$ and forest haulage: 4.4 €/m$^3$) (Kariniemi 2006). The profitability of intensive management is dependent on timber prices, costs of management practices, and the applied discount rate (Mäkinen et al. 2005). Therefore, the profitability of intensive, quality thinning ultimately becomes clearly evident in the final cutting: at what stage are the timber assortment ratios and the stumpage price levels of the different timber assortments.

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# Evaluating customer preference for wooden deck materials with age effects

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## Abstract

Customer satisfaction is considered a key performance indicator in business. It is a common assumption that high customer satisfaction ratings leads to repurchase of products and may also result in purchase of other products in the product line. In the present study, focus is directed at measuring customer satisfaction for wooden decking materials. Customer preferences for materials that had been subject to simulated use for two years were measured and these were compared with consumer preferences for new materials. The results indicate that customers prefer deck materials with age effects. The deck materials that had the lowest score when new, had the highest improvement of preference score after aging.

**Key words:** Consumer preferences, wooden deck materials, age effect, customer satisfaction

## Introduction

Wood used in outdoor environment is subject to biological decay. In order to improve product life, wood can be treated with traditional biocide preservatives or modified in a way where the mode of action is nonbiocidal. These different kinds of treaded or modified wood are used for a wide variety of purposes such as construction, landscaping, agriculture, electricity distribution and woodworking. The private Do-it-Yourself market is becoming increasingly important for the sawmilling industry. Home owners do, for example, build outdoor decks in order to expand living space and connect the home with the outdoors. Over 6.5 million residential decks were estimated as having been constructed in the United States (cf. Fell et al., 2006; Shook and Eastin, 2001; Smith and Sinclair, 1989). According to the Western European Institute for Wood Preservation, 21% of the total production of preservative-treated consumed in Western-Europe is classified as garden timber (Preservation, 2006).

The Norwegian sawmilling industry is producing approximately 500 000 cubic meters of pressure treated wood for uses such as construction, garden wood and woodworking (Norwegian Control Scheme for Pressure Treated Wood 2006). Annual production of pressure treated wood in Norway has increased substantially over the last 50 years and has almost doubled in the last ten years. Increased demand for garden products is the main driver for the rise in production. In 2006 garden products accounted for approximately 35% of total production (175 000 cubic meters) and additional 70 000 cubic meters wooden decking materials were imported.

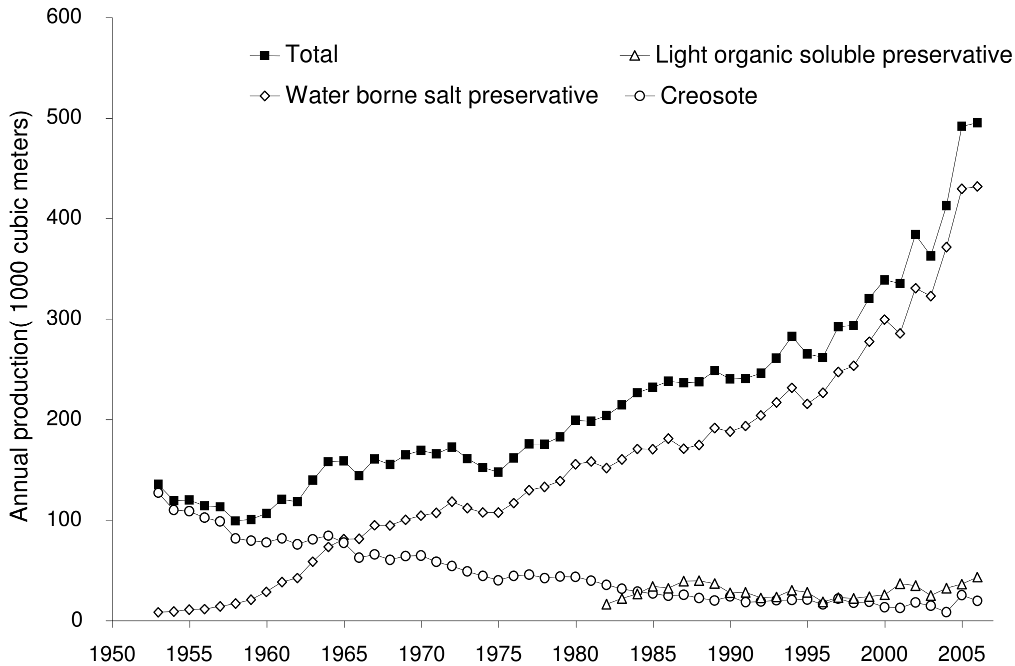


Figure 1. Annual production of pressure treated wood in Norway, 1953-2006. Source: The Norwegian Control Scheme for Pressure Treated Wood (2006).

## Theory

Satisfaction is commonly considered a psychological state and it is defined as a the fulfillment of a need or want. Customer satisfaction is a measure of how products and services supplied by a company meet or surpass customer expectation (Allen and Rao, 2000). In a competitive marketplace where businesses compete for customers, customer satisfaction can be a key differentiator and it has increasingly become a key element of business strategy. Businesses tend to focus on delivering customer satisfaction because satisfied consumers are more likely to repeat purchases, accept other products in the product line and are more likely to provide a good word-of-mouth advertizing for the product. Businesses interested in retaining existing customers, while targeting non-customers, can use measures of customer satisfaction provide an indication of how successful the organization is at providing products and/or services to the marketplace.

Currently, customer satisfaction is viewed as an emotional response to a product experience. The satisfaction construct has been defined in a number of different ways; (Giese and Cote, 2000) conducted a critical review of research articles on the issue and made an attempt to provide a generic definition of the subject that can be used in the research context. Based on the findings from the literature study they also used focus groups to evaluate their results. They provided the following definition of customer satisfaction: "Consumer satisfaction is a response to a particular purchase or consumption-related aspect occurring at a specific point in time." Furthermore, they proposed three factors of relevance for defining customer satisfaction:

1. An affective response of varying intensity.

2. Based on an evaluation of product attributes-benefits-performance, relevant people, information provided by others or researched, purchase/consumption experiences, and/or consumer-derived foci (e.g., needs, wants, decision, expectations, etc.).

3. Time-specific to before purchase, after purchase but before consumption, during consumption, or after consumption.

The authors recommended that the measures of satisfaction used should be consistent with the conceptual definition and the research goals because such a context-specific measure will prevent chameleon effects which can cause the meaning of items to vary depending on the other information presented in the questionnaire or research context.

Customer satisfaction can be measured by the means of multiple scale measurements, e.g. Likert-type scales that allows the respondents to evaluate different statements. In the present study customer satisfaction is measured as customers' preferences for new and used wood deck materials. According to results of previous analyses, the product properties that are related to visual product attributes and wood quality, are the most important product attributes for Norwegian Do-it-Yourself consumers (Roos and Nyrud 2008).

Fishbein provided a theoretical framework for cognitive motivational consumer models through his Multiattribute Attitude Model (Fishbein, 1963). Information about product attributes and attributer saliency can be used to predict consumer behavior. Consumer behavior is considered the weighted sum of independent attributes or affects:

(1) $$A_o = \sum_{i=1}^{n} b_i e_i$$

where $A_o$ is the attitude towards an object, there are n salient attributes identified (i = 1, ..., n), $b_i$ is the strength of belief towards an attribute and $e_i$ is the evaluation of the corresponding attribute. Fishbein's cognitive motivations theory has been further developed, cf. the Theory of Reasoned Action and Theory of Planned Behavior (Ajzen and Fishbein, 1980; Fishbein and Ajzen, 1975).

Customer satisfaction have hardly been evaluated in the forest research literature. To the best of our knowledge, the only previous study was conducted by (Jonsson, 2005). He used consumer satisfaction modeling to evaluate the substitution in markets for different types of flooring. Low life cycle costs, hygiene and Do-it-Yourself aspects were the most important factors that impacted on customer satisfaction and suggested that it is important to include substitutes when considering a customer satisfaction. (Smith, 2002) investigated consumer value in the hardwood lumber industry based on a survey among buyers of northern hardwood lumber. He found that attributes of importance to consumers are product availability and aesthetic qualities of shipments. (Idassi et al., 1994) developed a consumer oriented marketing method for hardwood lumber companies, highlighting the issues of customer satisfaction and customer value. (Weinfurter and Hansen, 1999) investigated quality requirements among suppliers and buyers in the softwood lumber quality business with focus on gaps in perception between supplier and buyer requirements. Bush et al. (1991) evaluated product and supplier attributes in the US market for hardwood lumber. They focused on the attributes that buyers were least satisfied with and found that users reported they were least satisfied with the quality of the lumber they purchased. Lumber producers overestimated customer satisfaction with the lumber quality.

In the present study customer preferences for various wooden deck materials is measured in order to evaluate customer satisfaction. The customer preferences for the deck materials that have been subject to simulated use for two years are measured and compared to similar customer preference data for the deck materials when they were new. Both visual and physical properties of wooden materials change significantly after exposure to outdoor climate. The study provides a measure for customer satisfaction (preference) related to age effects of wood products, i.e. the relationship between wood properties after simulated use and consumer preferences (cf. Oliver, 1992). Customer satisfaction can thus be considered a function of aesthetical and quality properties, where aesthetical properties are color, surface homogeneity, knot structure etc, and quality properties are durability, cracks, dry knots, year ring width etc:

(2) Customer satisfaction = f(aesthetics, quality)

## Material and methods

### Data collection

Data collection was conducted at a garden fair outside Oslo. Consumers were asked to evaluate samples of different wooden deck materials. One group of 130 consumers evaluated samples of new wood decks and a group of 117 consumers evaluated wood decks that had been outside for eighteen months (two summer seasons). For the new decks, two samples of each deck material were presented to the customers; one with small knots and one with large knots. For the old decks, three samples of each deck material were presented to the customers; one deck had been treated with appropriate oil treatment and the other decks were washed. A questionnaire was used to measure preference for both new and old deck materials. The visitors were rated how well they liked the different decks on a 1-9 Likert-type scale.

### Material samples

Four types of wooden deck materials were used in the analysis: (I) pressure treated pine (organic biocides), (II) modified pine (furfurylation), (III) naturally decay-resistant heartwood from larch and (IV) pressure treated pine (copper and boron). Deck materials (I) and (IV) are traditional pressure treatments with active agents inhibiting biological decay. Deck material (III) is naturally decay-resistant wood. Deck material (II) is modified wood. Information about the four deck materials is provided in Table 1.

The material samples were designed to resemble traditional home decks. These sample decks were rectangular, measuring 1000×625 millimeters and consisted of six parallel boards, each measuring 1000×950×28 millimeters, fastened to two perpendicular boards on the underside of the deck, cf. Figure 2. The boards were placed with the year rings facing up in order to cover the possible variation in the appearance of the deck materials; four replicate samples of each deck material were made. Material was purchased from builders' merchants, but furfurylated wood was not commercially available and was therefore provided by the manufacturer.

Figure 2. Deck material samples used in the study (left to right: organic biocide treated pine, furfuylated pine, untreated Russian larch, copper treated pine).

Table 1. Descriptive information sample deck.

| Sample | Commercial name | Tree species | Treatment | Origin | Price (NOK/$m^3$) |
|---|---|---|---|---|---|
| I | TMF | *Pinus silvestris* | Pressure treatment, organic biocides | Norway | 136 |
| II | Kebony | *Pinus silvestris* | Pressure treatment and curing, Furfuryl alcohol | Norway | 150 |
| III | Russian larch | *Larix sibirica* | Untreated heartwood from larch | Russia | 208 |
| IV | Wolmanit | *Pinus silvestris* | Pressure treatment, copper | Norway | 93 |

## Results

Mean preference scores for the decks are presented in Figure 3. The material samples with age effects, exposed to outdoor environment, got higher mean preference ratings for all material samples that were evaluated. Furthermore, the two deck materials that received low preference scores when new (Wolmanit and Kebony), got substantial increases in preference scores for material samples with age effects. There is also less variation in average preference score for all four types of deck materials with age effects.

The mean score for all samples are significantly higher for the material samples with age effects, cf. ANOVA comparison tests reported in Table 2. But when comparing the scores for each deck material, only the decks from Wolmanit and Kebony are significantly different for new and old decks.

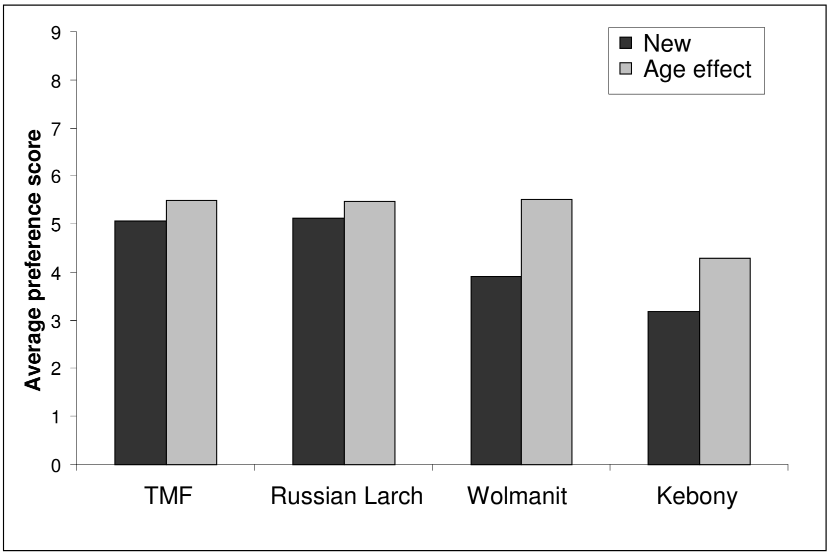


Figure 3. Preference scores for new material samples and material samples with age effects.

Table 2. ANOVA comparisons for new material samples and material samples with age effects.

| | Mean score | | Number of respondents | | p-value |
|---|---|---|---|---|---|
| | New | Age effect | New | Age effect | |
| | 4.33 | 5.20 | 466 | 506 | <0.0001 |
| All deck materials | | | | | |
| TMF | 5.04 | 5.50 | 116 | 116 | 0,125 |
| Russian larch | 5.14 | 5.47 | 130 | 117 | 0,229 |
| Wolmanit | 3.92 | 5.52 | 125 | 117 | <0.0001 |
| Kebony | 3.18 | 4.30 | 128 | 115 | 0.00024 |

## Discussion and conclusions

Customer preferences changes for decks made from new and decks made from old deck materials. In general, decks made from old deck materials had higher scores than decks made from new deck materials. Product properties that are affected by age and exposure to outdoor climate, i.e. age effect, includes changes in color and surface texture. It is therefore evident that age effects on sawn wood products can contribute positively to the customer preference for these products. In particular, the effect is positive for products that have inferior preference ratings for new deck materials.

According to common knowledge by most wood technologists, most deck materials will after being exposed to outdoor climate and age effects develop similar color and surface texture. In general, the visual properties of decks materials with age effects are similar in color. The age effect is reflected in the results since the deck materials with age effects got similar preference ratings, whereas new deck materials had more variation in preference scores between type of deck.

As described in the theory section, customer satisfaction relates to pre- and post consumption behavior. This study does not evaluate pre- and post consumption behavior *per se* because the persons taking place in the survey did not actually purchase the deck samples. But the results simulates the pre- and post purchase situation and it can therefore be argued that the study evaluates certain aspects of customer satisfaction.

The study highlights an aspect of related to wood products that have not previously been investigated. Consumer preferences for a product do change after the product have been in use. In this case, consumers are inclined to prefer products that have been in use. Further studies should evaluate how wood properties that occur because of age will affect customer preference. In particular, the effects of age effect on visual and tactile effects on the wood properties and how these specific age effects affects customer preference rating.

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# Business and Innovations in Wood Frame Construction – Cross - Sectoral Policy Challenges in Finland

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## Abstract:

Public policy actions to promote innovations related business based house construction and related wood use enhancement have been wide in Finland from the mid 1990's on but without many commercially successful innovations. This paper discusses national public policy activities in the two major clusters, real estate & construction and forest & wood product forest industry respectively. Major focus is in the challenges related to cross sectoral innovation processes that do not have position in cluster based national innovation policy favoring supply (technology) push innovation processes in financing in Finland from the mid 1990's up to the mid 2000's. Real estate & construction cluster enterprises tend to be risk averters in connection to new process and material solutions but have gradually from the early 2000's started to adapt customer orientation, networking and building information models based on shared information and communication networks into their business models. Challenges to climate change mitigation and new carbon sinks have improved the potential competitive advantages of wood frame construction with respect to concrete and steel frame solutions. Innovation processes by wood product industry firms imply new orientation if they aim to BtoB demand segment outcomes. Recent Living Business program, characterized by cross cluster center of expertise networks is part of the new innovation policy approach. This try to counteract the prior low interests on cross cluster interactions, that have weakened innovation attempts to react on demand signals.

**Keywords:** cross sector, policy, innovation, forest, forest cluster, real estate & construction cluster, wooden house industries, joinery industries

### Introduction

Wooden house and joinery industries have become identified as low tech industries in Finland with the average investments to R& D at level two percent units counted from the value added. Majority of the firms in these businesses have allocated limited resources to net investments, industry averages in 2005 being 12 % in wooden house construction industry and 17

% in joinery industry (the value added). Palmberg confirms that innovation processes in low tech industry firms are dependent not only on technological opportunities, but also on the performance of the innovation system and on supportive regulatory and competitive environment around the innovating firms (Palmberg 2001). Public financing on innovation activities has been much carried out through national technology programs. They have provided options to coordinate innovation attempts towards industry wide new competitive advantages. Public financing has widely complemented innovation process financing in low tech industries contrary to the common view (see eg. survey in STEP 06/2003). Competence requirements behind the innovation process performance among the firms are frequently and especially among SMEs broader and more multi-dimensional than what are intra firm available. Consequently the knowledge and other resource accomplishment of an innovation process imply the existence of external innovation environment. The latter means framework and resource supply (financial and knowledge resources) available for the firms to complement the intra firm resources. The general conditions described by the standardization and legislation infrastructure must provide the supportive impacts.

Supply push orientation and cluster specific approach characterized innovation policy in Finland up to the late 1990's. Public innovation project support strengthened cluster firms but put inferior interests on cluster interactions what concerns the coordinated value chain development. The latter issues had frequently impeding impacts on the innovation processes among the firms and even industries creating customer values in vertical value chain context. The latter characterization matches with wood product industries supplying products and services to real estate & construction cluster enterprises and other customers. The major points of this survey concern the business interests and transactions among enterprises in wood product industries and real estate & construction cluster respectively. The public actions to enhance knowledge resource supply for the construction value chain enterprises are also discussed.

The focus of the survey is in innovation processes, supporting and impeding factors from the fact that customer valuation extend over the cluster boundary between wood products and real estate & construction. The survey cover a) discrepancies between demand pull and supply push innovation processes, b) means and targets in public innovation financing and c) business culture differences among the two clusters concerned.

Innovation projects both in wood product industries and in real estate & construction cluster have traditionally focused on the progression of supply push product and process innovations. Innovation policy in Finland up to the late 1990's supported that approach. Public technology programs promoting demand pull innovations and more precisely organizational and marketing innovations, has been initiated to substitute supply (technology) push public innovation promotion from the mid 2000s. Real estate & construction cluster have gradually started to proceed new frame conditions on customer valuation that enterprises in the value chain must cope with in the near future. Product and service demand of the construction business in the upflow of the value chain implies information systems and standardized product and related planning systems of the firms in the wood product industries.

### Wood product value chains in house construction

The wood product value chains provide both upflow and downflow challenges for the wooden house and joinery industry enterprises. There is, in the upflow, a fundamental dilemma between the business interests among primary solid wood producers ie. sawmills on one hand and wooden house and joinery industries on the other. Sawmills have divergent optimization target in their production logic. The principle that the whole of the log comes in from the nearby forest must be put to use. This leads to a splitting into numerous product qualities and as a result numerous customer categories the problems of focusing in the stage of further processing are obvious (Nordigården 2007).

Wood dimensions and qualities in the demand of wooden house and joinery industries are specific and leave much of the sawmill output to be supplied for the other buyers. The parallel fulfillment of lean manufacturing in the two parts of the value chain is challenging.

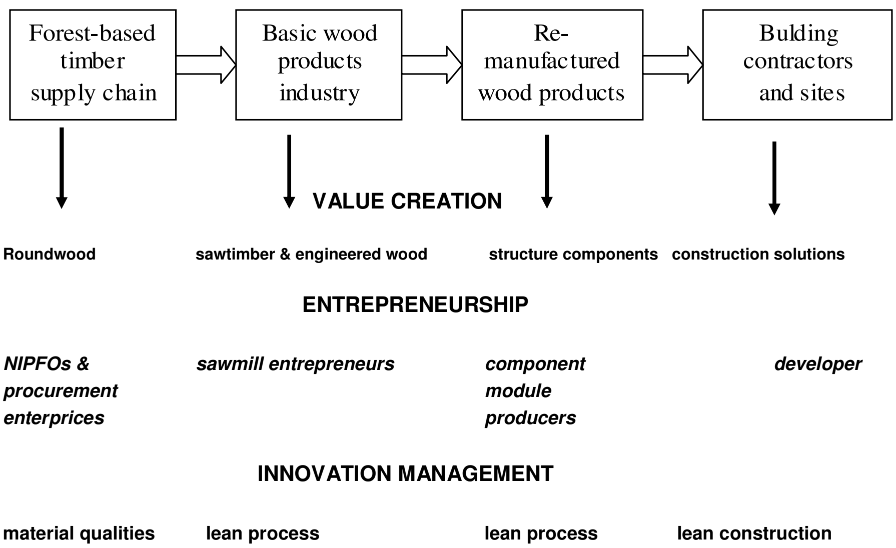


FIGURE 1. Wood construction product value chain – value creation, business stakeholders and core innovation challenges (from Ollonqvist 2006).

Missing links in the downflow of the value chains relate to the diversification of the chain into various types of customer- and market-oriented functional and system solutions. Building contractors and DIY customers have their specific demand segments and trade logic (Nord 2005). Wood products have earlier been compatible with demand in various segments but not any more.

| |
|---|
| **Construction services**<br>(arcitectural design, structural engineering & contracting services to housing developers, construction companies or self-procuring builder-owners |
| **Integrated timber construction system solutions**<br>panelised systems, volumetric systems for timber-frame homes, high- / low-rise multi-storey residential buildings |
| **Timber structures – System components**:<br>deliveries of subsystems, load-bearing frame structures: truss, subfloor & wall structures & elements, roofing, partition wall structures, eaves, exterior & interior wall coating, floor coating, windows, doors incl. casing, staircases, handrails, teraces |
| **Timber structure components**<br>glulam beams & pilars, I-joints, siding boards, rafters, mouldings, wood panels, tiles etc. |
| **Structural timber products** |
| **Sawn timber products**<br>specially sawed (heartwood split), cut-to-customer lengths, stress graded, kiln heat treated, planed, surfaced, finger-jointed, moulded, preformed, preservation<br>**Standard sawn timber** — **Engineered wood products**<br>plywood, particle board, fibreboard, LVL, glulam, OBS, PSL, OSL, etc. |
| **Timber raw material**<br>residues from sawmilling and planing<br>solid timber sourcing: standing timber selection, logging, scaling & bucking<br>veneer and lumber production: normal-sized, small logs from final cuts or thinnings<br>EWP, pulp, bioenergy production: lower-end quality fractions |

FIGURE 2 Vertical value chain – construction wood products & solutions (from Rimmler & Cooper & Ollonqvist 2006)

The business stakeholders in wood product value chains have been able to exhibit inferior co-ordination between the processes of different stakeholders ie. decoupling points among the actors have not had complicated specifications when compared with other value-adding chains, e.g. in the vehicle, aircraft and telecom industries (Brege et.al. 2005). In addition there is a fundamental challenge concerning parallel optimization of lean manufacturing among wooden house and joinery industries and lean construction among construction enterprises. Construction cluster could not send strong demand pull signals backwards in the value chain what concern technical requirements on systems and components but also and especially those derived from the final customers. On the other hand wood product manufacturers tend to apply divergent product logic: the whole of the log must be put into use leading to numerous product qualities in sawmill industries (Brege et.al. 2005). Wooden house and joinery industry enterprises are faced with numerous customer categories with their specific tastes and attitudes. All these challenges visible in the decoupling points of the value chain make the use lean principles difficult in the stages of processing solid wood value chains.

The demand of house construction products can be divided into professional Business to Business (BtoB) and end user Business to Consumer (BtoC) construction segments respectively. These segments are separable through the differences in the value chain configuration. House constructing firms in BtoB value chains demand input factors as intermediate input factors. The use of wood components and modules has preserved fair level, partly due to the public regulations (eg. fire regulations) and partly due to the challenges coming from the dominating construction culture. House constructing individuals in BtoC demand segments have gradually increased the use of industrially produced components and modules. The value chains of these products are frequently intra firm making to specific determination of decoupling points systemic. There are fundamental differences in the supply of modularized products in those two major market segments.

Enterprises behind the demand of BtoB construction segment apply standardized planning systems and input factors purchased from the market must match with the planning process specifications and requirements applied by those constructing cluster enterprises. Firms that finally determine the demand specification to construction companies can and frequently do vary, architects, construction planners, constructing enterprise or the project developer, depending the development process approach applied. The BtoB input demand is transferring from simple materials towards integrated modules and components when the standard compatible components are available. House construction in BtoB value chains is gradually becoming industrialized ie. more is based on the assembling of industrially produced components and modules (see Björnfot 2006 and Höök 2008). The industrially produced steel and concrete modules and components have frequently already gained a position of the standardized construction components and units. The substitution of wood with non wood alternatives, explaining the declining share of wood in material use, has partly been due to the low innovation activities behind the upflow supply ie. wood product industries. One explanation to the fair interests on research and innovation processes based on wood in BtoB construction can be the low supply of industrially produced wood construction modules and components.

There are final customers (consumers) and their unique construction projects behind the BtoC construction demand segments. The final consumers prefer custom made solution options in their construction projects and wooden house industry firms have put much innovation efforts to customize their BtoC solutions. The gradual increase in the demand of industrially produced construction modules and components in BtoC construction is partly due to the increased assortments of custom made alternatives in the industry supply. The production and supply of these modules and components into BtoC markets can be considered customer driven providing thereby company specific competitive advantages connected to the unique solutions. Firms in wooden house industries have preserved their favored position among the final consumers in BtoC construction activities. The latter has directed their business development interests mainly into the BtoC segment development. Wooden house producers have firm specific intra firm planning and production systems that are part of their competitive advantages. The latter orientate into the firm specific solutions of the wooden house suppliers.

The separate evaluation of the two demand structures has not been relevant and necessary until recently. Simple universal basic material parts constituted the major of the wood products used both in BtoB and BtoC value chains and their trade was based on direct trade or subcontracting. The separation became valid for the increased demand of industrially produced construction modules and components first in BtoC demand segments and later in BtoB demand segments, in the latter consistent with the new emerging construction planning. The new planning approach challenge the business opportunities of wooden house industry firms supply in BtoB market segments where compatibility with international open standards and neutral technology universal solutions are required. Another challenge comes from the life cycle approach life long service issues gradually adopted by the professional real estate enterprises and house management companies.

### The structure of the paper

This survey paper is organized into five sections. The first (Section 1) evaluates the extent and identification of clusters, wood products in forest cluster and real estate & construction cluster respectively and thereafter identify the intra cluster specifies creating the controversial development identifiable during the cluster approach dominance in Finland's innovation policy. The use of industrially produced wood construction modules has progressed adequately in BtoC demand segments in Finland whereas their use in BtoB demand segments has preserved inferior. The second evaluation (Section 2) discusses the process and management development of BtoB house construction and the competition among materials when industrially produced modules & components are concerned. The outstanding position of time management and path dependent business solutions in BtoB construction have supported the use of standardized solutions in planning and favored use of subcontracting in input factor markets. Third issue (Section 3) in the paper is the extensive spectrum of public technology programs and public and private joint interest activities in real estate & construction cluster in Finland from the late 1980s. These public technology programs have promoted real estate & construction cluster through material based approaches, construction process development actions as well as environmental and ICT solutions. Fourth issue (Section 4) discusses the public policy attempts to enhance the use of wood in construction and develop innovation infrastructure towards wood based component and module industries. The major challenge faced by the wood product industries comes from the past inferior position of material choice in the construction cluster. The concluding discussion (Section 4) concentrates to the concept material interplay in BtoB construction. Wood has had permanent competitive advantages as frame and outer surface material in BtoC construction but also in BtoB in Modern Wooden Town concept and wood frame solutions therein.

## Value Chains and Cluster Boundaries

Cluster approach applying modified Porter diamond model has been adopted among the public policy tools to identify interconnections and evaluate potential regional policy impacts when aiming to enhance industrial and regional development (eg. recent IRE Working Group on Regional clustering and networking as innovation drivers by 15 member regions http://www.innovating-regions.org/groups/projects.cfm?sub_id=26). The cluster approach activity concentrates to key products, actors and include their interconnections with business relationships but omits public actors. Cluster identification is based on core products/ services. The producers of these products constitute the core of the cluster. Value chain identification constitutes the necessary first step when identifying the cluster. Transaction interface between the customer and the producer provides the key cluster identification. Cluster identification put efforts to pick up necessary relationships and industries connected to the production of the identified the key products. National and European Union cluster activities thereby frequently comprise business networks and other regular relationships among the firms.

Cluster approach can in the value chain context become impeding if the inter cluster coordination in the value chain is weak or missing. Inter cluster peculiarities and controversial development due to the cluster approach dominance among forest cluster and real estate & construction cluster are identifiable in the innovation policy in Finland up the late 1990's. Cluster oriented public programs and support tend to put priorities to intra cluster product and process development due to firm specific support. Past innovation policy has accentuated technology push innovations thus fostering module and component innovations. Business cultures, production processes and thereby business arrangements have been different. The module and component innovations created by wooden house and joinery producers in solid wood industries have not had good match with the BtoB construction processes. Modern Wooden Town concept and related value chains discussed later in this paper have been an exception.

**Wood Product Industries - Forest Cluster in Finland**

Forest cluster in Finland cover, in addition to industries producing primary wood based products (sawnwood, wood plates, pulp and paper), secondary wood based industries (wooden house and joinery producers, wood furniture and paper and board product industries as well as extensive KIBS sub sector and industries for machinery &, equipments & automation. Wood product industries covering primary product (sawnwood, planed wood, wood plates) and secondary product (wooden houses and joinery products) enterprises are among the major input factor providers to real estate & construction cluster (see. Virtanen & Hernesniemi 2005).

Pulp and paper industries have dominated forest cluster development and cluster innovation policy in Finland. Domestic wood product value chains do not hold strong position in Finnish forest cluster dominated by pulp and paper industries ( 60 % of total turnover) & export orientation in the whole cluster (57 % of turnover). The extensive position of pulp and paper & paper product industries has remained stable throughout the increase by around one third increase during the decade from 1995 on when measured by the total turnover added value and the value of export challenges

TABLE 1 Forest Cluster in Finland 1995-2005

**Forest Cluster**

| | **turnover** | | | | **added value** | | | | **export** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1995** | | **2005** | | **1995** | | **2005** | | **1995** | | **2005** | |
| | **M €** | % | **M €** | % | **M €** | % | **M €** | % | **M €** | % | **M €** | % |
| *Primary wood prod industries (sawmilling, planing..)* | *2156* | *14* | *2905* | *15* | *576* | *11* | *394* | *7* | *1362* | *16* | *1481* | *14* |
| *Primary wood plate industries* | *656* | *4* | *902* | *5* | *244* | *5* | *310* | *6* | *469* | *5* | *733* | *7* |
| ***Secondary wood prod (wooden houses, joinery..)*** | ***844*** | ***6*** | ***2027*** | ***10*** | ***299*** | ***6*** | ***665*** | ***12*** | ***301*** | ***3*** | ***554*** | ***5*** |
| *Wooden house industries* | ***279*** | ***2*** | ***669*** | ***3*** | ***99*** | ***2*** | ***219*** | ***4*** | ***120*** | ***1*** | ***222*** | ***2*** |
| *Joinery industries & other* | ***565*** | ***4*** | ***1358*** | ***7*** | ***200*** | ***4*** | ***446*** | ***8*** | ***181*** | ***2*** | ***332*** | ***3*** |
| Pulp and paper industries | 9830 | 66 | 11655 | 59 | 3313 | 66 | 3317 | 61 | 5850 | 68 | 7634 | 70 |
| Paper product industries | 680 | 5 | 868 | 4 | 228 | 5 | 302 | 6 | 295 | 3 | 276 | 3 |
| furniture | 749 | 5 | 1316 | 7 | 355 | 7 | 474 | 9 | 347 | 4 | 260 | 2 |
| **TOTAL** | **14915** | | **19673** | | **5015** | | **5462** | | **8624** | 58 | **10938** | 56 |
| **change** | | | | 32 | | | | 9 | | | | 27 |

The growth in aggregate production turnover and export in the cluster has been occurred at the expense of deteriorating added value especially when primary wood product industries are concerned. The deteriorated added value can be traced behind the raised interests towards supportive development actions for the secondary wood product industries These interests, partly due to extend the export capacity in BtoB construction value chains, are discussed next.

The share of wood product industries (primary & secondary) from the total turnover has increased from 25 % in 1995 by five percentage units to 30 % in 2005. The wood product industries (primary & secondary) share from added value 22 % in 1995 has increased by three percentage units to 25 % in 2005. The wood product industries (primary & secondary) share from export was 24 % in 1995 and 26 % in 2005.

**Secondary wood product industries in Forest Cluster**

The outcome from the major differences between primary and secondary wood product can be identified in the added value share of production. Primary wood product industries account two thirds of the added value share acquired in wood plate and secondary industries has remained around 35 % of the total turnover.

TABLE 2 Wood product Industries in Finland 2005

**Wood Product Industries**

| | **turnover M€** | % | **add value M€** | % | a v share |
|---|---|---|---|---|---|
| *Primary wood prod industries (sawmilling, planing..)* | 2905 | 44 | 544 | 36 | 19 |
| Primary wood plate industries | 902 | 14 | 309 | 20 | 34 |
| **Secondary wood prod industries** | **2027** | 31 | **665** | 44 | 33 |
| *Wooden house industries* | *669* | *10* | *183* | *12* | *27* |
| *Joinery industries* | *1178* | *18* | *402* | *26* | *34* |
| other | *180* | *3* | *80* | *5* | *44* |
| **TOTAL** | **6534** | | **1524** | | 23 |

Public effort has been directed to the development of secondary wood product industries mainly towards the enhanced wood use in BtoB construction. The latter interest can be understood by the dominance of wood frame and exteriors in BtoC house construction. However, it is not possible to create expansion over the natural increase in the aggregate wood product demand in BtoC demand segment. The latter is due to the current high share of wood frame in the total demand. The exception are the markets of log house export where the competitive advantages of Finnish firms are clear contrary to those in ordinary wood frame.

The major business strategy of wooden house industry enterprises aim to attain high diversification of house alternatives supplied for the consumer choices at competitive prices. The development of competitive advantages among wooden house industries are based on a) the development of supply driven product development and b) process development towards high cost competitiveness. The major innovation driver comes from market competition and intra firm innovation processes aim for incremental product and process innovations.

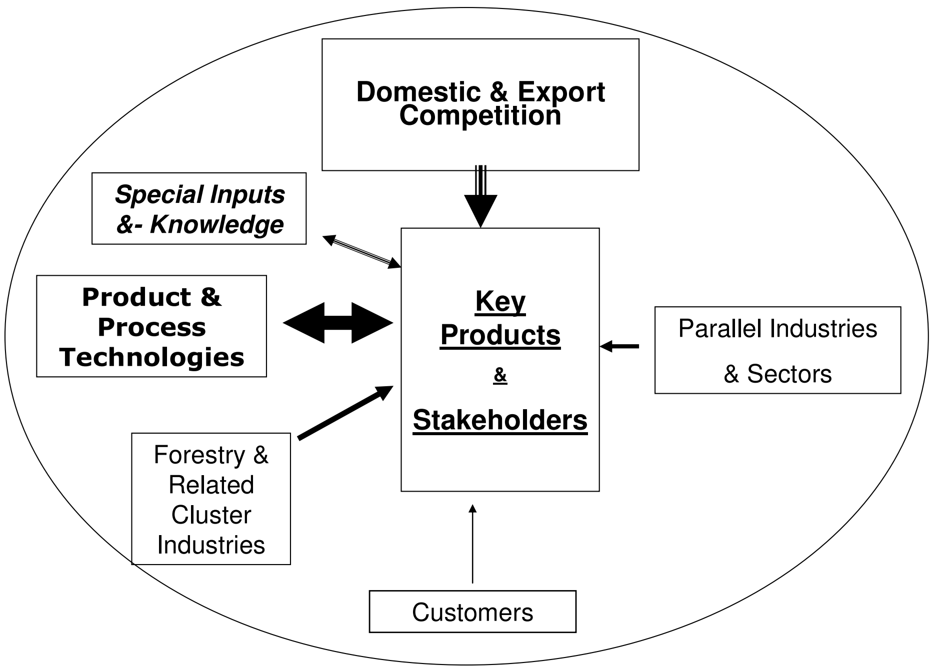


FIGURE 3 Forest Cluster and Innovation Orientation in Wood Product Enterprises

**Real Estate & Construction Cluster**

Construction components and modules produced by the wooden house industries are demanded in the downflow of the value chain, in real estate & construction cluster by a) final customers for consumption in BtoC segments (pre fab houses 52 %, log houses 15 % and b) intermediate inputs in BtoB segments (8 %. In addition there is the export demand (pre fab houses 6 %, log houses 19 %). These market segments do not overlap because of the company specific customer value solutions and corresponding value chains in BtoC segments. Input/ Output (IO) relations connect industries and sectors through the intermediate demand. The latter is the demand of upflow outputs for input factors in downflow of the value chain. There is also output demand for final consumption. IO relations are among the major indicators applied in internationally developed cluster evaluation. These connections have also qualitative dimension meaning the mode identification of the transactions between the industries. Transactions among value chain /value network partners constitute permanent participation into the value creation compared with the trade subcontracting.

End user constructors behind BtoC demand segment are transitory actors in the real estate & construction cluster (66 % domestic and 15 % export of total wooden house industry turnover) without permanent incomes from the construction companies or taxes or other payments from their activities. They buy construction components and modules as final consumers paying added value tax as a part of the outlay from the transactions.

**Subcontracting dominate real estate & construction cluster input business**

Real estate & construction cluster count house and infrastructure construction as the core activities in Finland. Real estate management & maintenance and property services & repair are included into this cluster. Apartment buyers and real estate developers are the final customers for house construction. Construction component industries and construction technology & knowledge intensive business services (KIBS) would be included into the core activities when construction cluster is formulated as international (see. Virtanen & Hernesniemi 2005).

Professional constructors behind BtoC demand segment (8 % domestic and 10 % export of total wooden house industry turnover) have their major incomes from construction sector and pay taxes and other payments from these activities. Professional constructors buy components and modules as intermediate inputs paying added value tax only from their contribution into the final value of the output when it shall be sold to the final customer (consumer). The final customer can be an investing company or other real estate developer and the intermediate input transaction is internal inside the real estate & construction cluster. Innovation processes are currently highly demand driven ie. the empirical or scenario attitudes and preferences are at their basis. Innovation processes are becoming networked meaning co operation and partnering with architects, construction planners and construction expertise together with the input component providers. Knowledge sharing and joint information platforms constitute the infrastructure of the innovation processes.

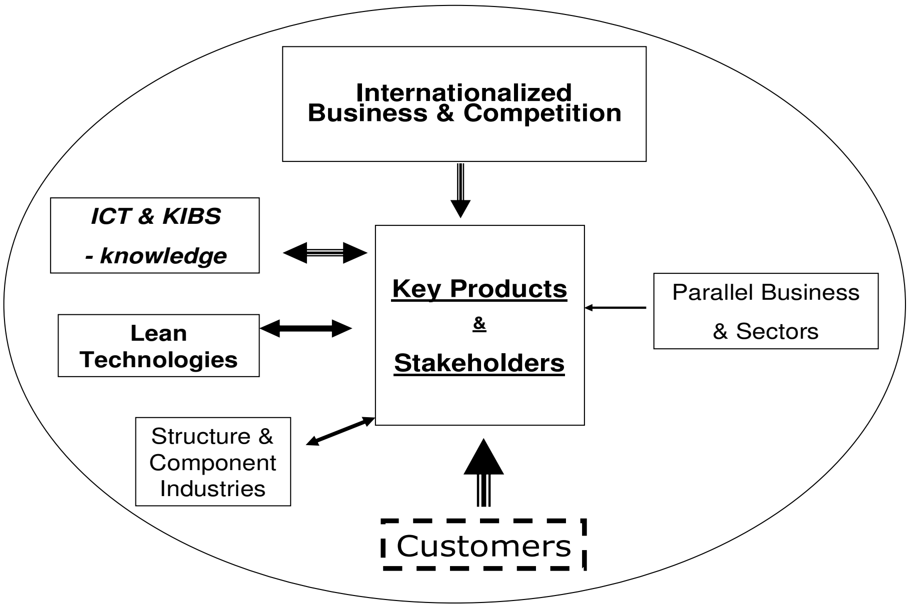


FIGURE 4 Real Estate & Construction Cluster and Innovation Orientation in Cluster Enterprises

## Process development in professional construction

The outstanding position of time management and path dependent business solutions have dominated mainstream BtoB construction processes. Björnfot considers construction practitioners supported the unique construction process structures (eg. many different participants, one-of-a-kind projects, a conservative industry, etc.) in Swedish professional wood frame construct context (Björnfot 2006). Koskela have presented similar issues, though from an international perspective (Koskela 2000).

Subsequent, separately arranged construction planning and construction process have supported the use of unique project mode and the preservation of routines based on standardized in situ construction. Subcontracting solutions characters upflow relations in professional construction between the constructor and input factor providers. High material wastes and inefficiencies and mistake costs are frequently identified in these processes. The major outcome for the mode above have been a) high knowledge and professional requirements in situ, b) waste & residues growing up to 10-20 % even to 35% of total costs of construction project and unarranged recycling waste & residues creating environmental externalities c) need for repairs and additional work phases defects to be up to 10% of the production costs; about 30% of the costs originated from design, 40% from site work, and 20% from machines and materials (Forsberg & Saukkoriipi 2007)

Traditional unique project approach and in situ construction mode in professional construction has made the industrialization in BtoB construction slow when industrial wood product components and modules are concerned. The initials for construction process development (towards lean construction) in EU area can be traced to the Egan report in UK (Construction task force 1998). This attempt was preceded by Constructing the Team- analysis (Latham 1994). The similar attempts did not come much later in Scandinavian countries. Vision 2020 study in Sweden (Flanagan 2002) and real estate & constriction cluster vision 2010 in Finland (Real Estate & Construction Cluster Vision 2010. 2005) share the same findings and task force attempts (see Koivu & Björnsson 2003). Recent key actor seminar for the real estate & construction cluster evaluated the feasibility & main routes for construction and building material industry value chain formation. They also projected the outcomes: a) customer based value creation approach, b) standardized services, systems, products (modules & components), c) process management development and d) feasible management approach for business internationalization (Koivu & Björnsson 2003). The identified main principles by the representatives from large-scale industry & SMEs did share the targets derived from lean thinking principles in that context.

## Lean principles in construction

Lean principles are in the Womack & Jones specification grouped into five areas. The first one (value) put focus on customer value identification that will be interpreted in the second (value stream) meaning the value creation process through standardized principles and tools covering the whole process from materials to finished good and services. The third principle (flow) stresses continuous development of processes and practices with quality improvement included within the fifth principle (perfection) to eliminate waste not only as material but also in unnecessary use of human resources. Lean approach, by the fourth principle (pull instead push), mean production for a specified customer and firm produces only what customer want to pay Lean work culture is implemented with team formation and applying transparent processes (everybody knows everything). (Womack & Jones 2003).

Lean Thinking in Construction implies: a) the customer value definition, b) construction process formation to be able to achieve this customer value target c) assembling where waste and unnecessary actions are eliminated and d) all steps that create value are linked in a continuous sequence, e) each of the steps are continuously improved so that customer value could gradually be enhanced (Björnfot 2006). Production in construction is currently based on thinking from both craft (traditional construction practices) and mass production (mainly prefabrication). Lean thinking, originally developed for the manufacturing industry, should be applicable to construction.

Lean Thinking in Construction, systematically developed by an International Group for Lean Construction, has stated the principles of lean value creation in construction. covering: project definition & design management, production system design, prefabrication, assembly and open building, lean within ICT, safety, quality and environment, contract and cost management (website of the International Group for Lean Construction http://www.iglc.net/)

*Project definition* phase of is crucial: what is the aim with the production, how to reflect customer requirements and translate them into product specifications in all value creation stages (Freire and Alarcón 2002). *Design* provides the product with characteristics that fulfill customer requirements. *Construction* is considered manufacturing like economic activity through the principles of flow process design (Kagilou 2008). *Lean Project Delivery System* (LPDS) handle construction phases as interrelated contrary to the traditional view of the construction composed of independent phases (Ballard and Howell 2003). LPDS contain rules, procedures, and a set of tools to control the flow of work between trades enabling improved flow of production and characteristics to pull through work plans (Ballard & Picchi & Sacks 2008). *Prefabrication* covers in house manufacturing and assembling in modules components prior to final in situ installation. However some prefabrication can be done at construction site, but for majority it occurs off site. *Open building system* involves design, construct and operate rules in the built environment that the user can relate to and is willing to maintain and defend. Open building advocates a layering of the built environment along the lines of control to coordinate yet decouple decisions allocated to different levels. There are rules to guide design-for-manufacturing and design-for-assembly in the construction world. They advocate a) detailed engineering to fabricators and installers as a co-product process, b) linking orders for prefabricated products to the installation activities, c) designing and making parts of the facility in comprehensive units, d) structuring supply chains for flow (Ballard & Cuperus & Matthews

& Milberg 2008). *Legal and financial infrastructure by contract and cost management* covers design, construction and operation of buildings and structures. Key targets in this context are the proportions between risks, incomes and profit shares. Construction is a high risk business with uncertainty and variation included in each phases (definition, design, assembly, commissioning). Contract & cost issues extend to a) structure by the project definition, objective setting and identification of constraints (relational contracting, setting target values and costs) for value generation as well as waste elimination b) project execution toward the objectives and within the constraints (project governance; designing to target values and costs)and c) learning from breakdowns (unintended deviations from standard/plan) and from experiments (intended deviations from standard/plan).

Lean construction is a comprehensive set of actions developed by an international R&D consortium towards cost competitive value creation. Lean construction is much an intra firm issue but extend to contracting partners. Communication and cooperation between the stakeholders in the value creation belong to lean management issues.

**Towards universal construction information systems**

A recent international joint interest network Erabuild carried out standardization and information tool activities towards international open standards and neutral technology (Erabuild 2008.). The coordinated task outcome target, to enable efficient information flow during the complete lifecycle of the building and beyond unified the national R&D programme targets and International Alliance for Interoperability (IAI) outputs, to provide sustainable tools for information & communication management to be applied in construction and facility management & repair activities and provide access to that information for the participating members. The network, initiated in 2004, comprised funding organizations from 9 countries (Austria, Denmark, Finland, France, Germany, the Netherlands, Sweden, Norway and United Kingdom). Network applied Building Information Modeling (BIM) approach. BIM is a building design and documentation methodology covering Architecture, Engineering and Construction (AEC) model targets to be delivered with digital representations for communication among the building activity partners. BIM facilitates information exchange and interoperability in digital format with 2D or 3D representations in those CAD- oriented systems used in Europe. Traditional CAD vendors within the AEC sector can provide BIM applications and support reliable and efficient data exchange between different applications providing creation and merging with cross domain models. Architecture, Engineering and Construction models covering also Facilities Management (AEC / FM) are needed for wood construction modules and components. The use of BIM in the design phases makes it possible to monitor change during the design process. This can be seen as an advantage for some parties in the AEC/FM industry because it is easy to track changes, while others may feel this as limiting their ability to make changes during the design process. The restrictions in R&D resources by the companies of wooden house and joinery industries in Finland impede frequently their abilities to adopt BIM.

## Public innovation promotion on construction cluster

Public interests towards innovation processes can be classified into a) innovation system creation and maintenance, b) resource allocation to knowledge creation & distribution and c) single & joint contributions to innovation systems by firms. There are three innovation systems, national (NIS), sectoral (SIS) and regional RIS, identifiable in Finland. The technology programs discussed next are involved into national and sectoral objectives & tasks. Technology programmes, among the major innovation policy tools in Finland, are broad constellations of development projects focusing on a particular field of technology. The areas of technology to be supported have normally become selected through strategic scanning carried out by the Finnish Funding Agency for Technology and Innovation (Tekes), industry and other relevant stakeholders respectively. Strong cluster orientation has been earlier dominant in the innovation policy actions and support of Tekes. Technology push innovation projects towards new products and production processes have dominated in their financing. Inferior cluster interactions and value chain coordination excluded the progressive impacts discrepancies between demand and supply and business cultures what concerns wood use in construction. The basic idea of the programming approach has been to channel technology development efforts into large entities tailored for a particular field of technology, theme or some cluster specific issues.

There is a major change in R& D orientation within the real estate & construction cluster identifiable during 1990s. This transfer can be summarized: 1) The quality and results of business-driven R&D have improved, 2) The competing and dispersed group of actors (enterprises, public agencies and associations) have created dense, common goal-sharing inter-organizational networks, 3) The R & D focus has extended from the building process to the whole life cycle of the constructed objects (Uusikylä et.al. 2003).

The most important is however considered the shift from supply (science) push to demand (market) pull orientation thus picking up the tradeoff between the individual customer tastes and willingness to pay and the cost efficiency through standardization.

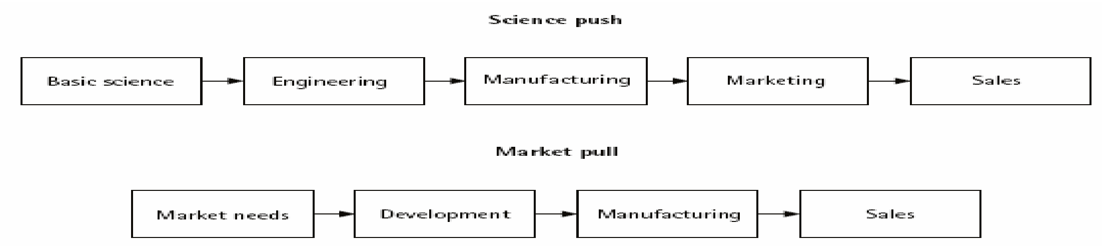

FIGURE 5 Innovation process - initial and process stages
(Schienstock & Hämäläinen 2001, Rimmler & Cooper & Ollonqvist 2006)

The role of Tekes, the main government financing and expert organization for research and technological development in Finland, has been important in the strategy development towards competence improvements in real estate & construction cluster. Technology programmes (18 of which 9 started between 1992-1995 and 9 started between 1996-2002) have covered a wide range of activities from building materials (wood, concrete, stone, steel totaling 78 M €) to building techniques and processes (totaling 100 M €)as well as thematic fields (environment, health aspects, ICT integration etc. totaling 46 M €) and renovation (6 M €.).

TABLE 3 National Technology Programmes 1992 -2006 - Real Estate & Construction Cluster and Wood Product Industries see http://www.eccenet.org/Activities/Res-Dev/finland0502.pdf

| Programme | Time span | Finance M € | TEKES M € | Main Stakeholders in addition to Technology Development Centre (TEKES) |
|---|---|---|---|---|
| **1992 - 1995** | | | | |
| Tech Progr for **Concrete** Industry | 1992–1995 | 1,4 | 0,7 | SBK; Construction & Constr mat Ind VTT; Tampere Technical University |
| **Renovation** | 1992–1996 | 4,4 | - | Ministry of Environm; Min of Trade & Ind Tekes; Const ind; Real Estate Enterprise Ass |
| RYM - **Environmental** Tech in Constr | 1994–1999 | 23,7 | 11,9 | VTT; Min of the Environm; Industry; Helsinki Univ of Tech, Fin Arch Assoc |
| Hansa **Renovation** | 1994–1996 | 1,2 | - | Ministry of the Environm; Ministry of Trad & Ind; Constr ind & related associations |
| Industrial **on-the-spot building** | 1995–1998 | 2,1 | 1,0 | 10 large firms in construstion value chain |
| New meth for **constr processes** | 1995–1998 | 1,8 | - | Fin Assoc of Build Owns, ConstClient Ass |
| **Wood** in Construction | 1995–1998 | 22,0 | 8,8 | Wood Info Inc & Rwood Researc Inc Helsinki Univ of Tech Forest Ind fims |
| Finn**steel** Technology Progr | 1995–2000 | 10,5 | 4,7 | Steel Struct Ass, Steel Ind |
| Smart & Modular Building **Automation** | 1995–1999 | 17,6 | - | Finnish Ass of Build Own & Constr Clients Electricity Contr Ass 140 firms |
| **1996 - 2002** | | | | |
| ProBuild – Prog **Building Process** | 1997–2001 | 80,0 | 4,9 | Constr cluster firms & assoc |
| Vera – Constr **Prog Infrasturcture Netw** | 1997–2002 | 43,0 | 20,0 | Construction Firms; architects; IT firms |
| Added Value **Wood** Chain | 1998-2003 | 34,0 | 17,0 | The Wood Industry Inc & Forest Ind fims |
| **Healthy** Constr, Indoor Climate & Qual | 1998– 2002 | 22,0 | 11,0 | Ministry of Environm; Res Insts, Universities Construction Ind |
| Rembrand – **Real Est Mgmt & Services** | 1999-2003 | 22,0 | 11,0 | Finnish Ass of Build Own & Constr Clients Res Insts, Universities, Construction Ind |
| KIVI - Tech & Dev Progr for **Stone** Industry | 1999-2002 | 10,0 | 5,0 | TE Centre North Carelia, Nat Stone Firm Ass |
| Progress - **Green Development** in Real Estate & Construction Business | 1999-2001 | | | 60 firms |
| Infra - **Infrastructure** construction | 2001-2005 | 32,0 | 16,0 | Ministry of Trafic & Comm, City of Oulu, Firms |
| Cube Building **Services** | 2002-2006 | 40,0 | 20,0 | House Tech Dev Centre of Fin Inc (coord.) |

The major cluster stakeholders were in an interview research asked to consider the supporting and impeding impacts achieved through the real estate & construction cluster technology programs. The latter was carried out as a part of an extensive specialist evaluation on real estate & construction cluster technology programs (Uusikylä et al 2003). The programs that were considered most supportive by the experts aimed to improve the quality of R&D activities, the level of knowledge and know-how: Smart & Modular Building Automation, Vera – Construction Program Infrastructure Networking, ProBuild - process information management based on comprehensive ICT system and Rembrand - Real Estate Business Management. Majority of the technology programs reviewed have considered to produced modest impacts what concerns international networking and cooperation The material based technology programs, steel and wood material programs, received low scores from the experts. Finnsteel program had rather low expectations beforehand and the outcomes were evaluated fair. Wood in Construction programme was evaluated by the experts as one of the biggest disappointments among all programs. Program had more than average expectations wrt other material programs but outcomes, considered by the experts, nearly non-existent (Uusikylä et al 2003).. The judgment on material programs was that their strategic positioning was not adequate. They should not have been initiated before demand research ie. the major technology programs in construction technology.

**Real Estate & Construction Technology Promotion - Value chain approach**

Promotion towards innovative solutions in real estate & construction cluster has further developed on the basis of Real Estate & Construction Cluster Vision 2010 action by construction cluster NGOs. The latter, broad based strategy action towards the identification of new competitive advantage options in the global competition business infrastructure, initiated program activities towards the adaptation of lean principle in construction (Real Estate & Construction Cluster Vision 2010. 2005). New technology program Sara (Value Networks in Construction), carried out during 2003–2007 (with total budget 33 M€ where Tekes share 15 M€), had parallel technology program interests. Tekes, the program initiator and major financer, defined program focus a) a unifying link between the individual diversified technology programmes within real estate & construction cluster and b) international competitiveness improvement among cluster firms and networks. Sara program projects developed eco-efficient solutions for multi-storey and low-rise buildings and provided tools to facilitate the adoption of building information modeling in construction. Substantial resources were allocated towards life cycle procurement models, customer-oriented commercialized housing and office solutions, low rise urban construction as well as project and customer feedback management systems. There were more than 100 individual projects occupying350 organizations. Construction product industry had already improved their value-generation capability by upgrading product deliveries to system deliveries: one of the major targets of Sara was to upgrade system deliveries towards deliveries compiling services in addition to products. Program interests were organized along the principles supporting lean construction enhancement through initials to customer value identification, construction service generation, quality management and productivity improvements (Sara TEKES 2008)

## Public innovation promotion on enhanced wood use

The conservatism towards R&D together with fragmented and inflexible business structures in real estate & construction cluster have created challenging frame conditions for the processes towards innovative wood components and modules into BtoB demand segments. The latter can provide a reason for the low appreciation among real estate & construction cluster stakeholders what concerns innovation system creation and maintenance (mode a) solutions Neither Wood in Construction technology program (WinC) during 1995 – 1998 nor Value Added Wood Chain technology program (VAWC), during 1999–2003 discussed next, did find cross sectoral new solutions with real estate & construction cluster. Public interests in resource allocation to knowledge creation & distribution (mode b) and single & joint contributions in innovation systems (mode c).towards innovation processes in wooden house and joinery industries have been intensive and successful as discussed later.

### Wood in Construction I – Technology Programs in Finland

WinC technology program aimed to 1) create internationally competitive basic production in wood construction, and 2) improve the manufacturing process to make production more efficient, environment friendly, and to enable high-quality wood construction in Finland. WinC was characterized by the evaluation survey members as a part in the wood hype at that time in Finland (Uusikylä 2003). The government had launched its Puun Aika (Age of Wood) programme but the background in constructing with wood was missing. Wood structure solutions had according to the evaluation never broken through into mass-scale building processes in Finland. The evaluators faced with difficulties when assessing the real impacts of the programme. No evidence was found to the programme document statement concerning direct impacts of the program behind the increased use of sawn timber in building by 35% and exports of manufactured wood products by 15% during the program implementation stage. WinC was concluded one of the last material based technology programmes by Tekes and program outcomes relatively poor like in other material based programs. There was no overall strategic focus for the programme but a reflection from the narrow interests among wood construction component and module producers what real estate & construction cluster will benefit (Uusikylä 2003).

VAWC technology program listed programme targets: a) increased the use of wood and enhanced value added characteristics and b) promotion of international co-operation in wood processing and related industries. Research disciplines covered wood material science, wood technology, wood process technologies and business networking. The programme supported new business solution development for the increased construction use of wood in EU. Cross-disciplinary cooperation in research, product development and marketing were aimed to stimulate European and global networking. Wood product SMEs were encouraged to work with large enterprises in the sector to increase their expertise and enhance their customer base. Program was designed to support the development and expansion in building components and systems including design, assembly and other technical services networking enterprises across Europe. The fair knowledge dissemination from the concrete outcomes of the technology programs has been among the challenges faced by wooden house and joinery industry firms.

**Wood in Construction II – Promoting Enhanced Expert Knowledge Supply**

The establishment and maintenance of knowledge creation & distribution systems can provide indirect support to individual innovation processes by providing R&D and management knowledge for the demand of individual firms. Resource allocation to knowledge creation & distribution has been carried out in Finland through two channels a) Centre of Expertise for Wood Products (CEWP), national network of universities & research institutes and b) WoodFinland (WF) network management expertise service are discussed in this chapter.

CEWP, carried out during 1999 – 2006, was arranged as a part of national Centre of Expertise programme framework (OSKE I). The program framework, introduced in 1994, aimed to foster regional specific development in the field of expertise that the area has existing competitive advantages. Networked mode was applied in CEWP contrary to other regional CEs. National network of universities & research institutes for wood product innovation processes provided knowledge and expertise services also for the related SMEs (Paajanen et.al. 2007). CEWP was arranged into seven themes of expertise:

| Theme | Key stakeholder |
|---|---|
| Modern Wooden Town | - *Wood Studio, University of Oulu* |
| Large-Scale Wood Engineering | - *Tampere University of Technology* |
| Living with Wood and Design | - *Helsinki University of Art and Design* |

Diversification of Wood Utilization - *Finnish Forest Research Institute*
Development of Technology - *Lappeenranta University of Technology*
New Business Concepts - *University of Vaasa / Levón Institute*
Developer Forum - *Helsinki University of Technology*

Modern Wooden Town was organized as a planning concept for low rise intense detached and semi detached town and land use planning (Karjalainen 2003). The wood construction component and module innovation supply options in low rise apartment house construction concept were available in town planning concept. Aesthetic and material properties available in wood configuration could also be taken into effective use in this context. Wood structures together with related components and modules achieved their competitive advantages as part of Modern Wooden Town concept and the wood solutions supported Modern Wooden Town concept. This concept mode, covering 150-300 low rise apartments (in single, detached and low rise storey houses), has been implemented in about 20 developer managed BtoB construction projects in different part of Finland. Modern Wooden Town concept is one of the projects in the newly started next generation living innovation development project "Living Business" knowledge & competence enhancement cross cluster program to be discussed later.

**Wood in Construction III – Promoting Wood Product Value Chains**

Wood Finland program mode, adopted as a part of rural development, has been solely forest sector program with minor inter sectoral solution with real estate & construction cluster enterprises. Wood Finland, Phase I during 1992-1994, was implemented in a close connection with National Rural Development Program of that time and proceeded i) creation of pilot (reference) projects based on locomotive firms and ii) wood (softwood log) delivery co operative of non industrial private forest owners. Wood Finland, Phase II during 1998- 2005, had three objectives: 1) networks between SMEs on regional basis and connections to locomotive firms operating in international markets, 2) creation of new wood components and modules especially for construction and 3) enhancement of technological and business management knowledge creation among in SMEs (Salonen & Järnefelt 2006). Eleven partnership networks of SMEs was the project outcome: 4 managed and coordinated by locomotive company with international business activities and 7 regional networks of SMEs for national market activities.

**Wood in Construction IV – European Town & Community Planning Promotion**

Wood construction promotion was continued through two parallel Wood construction promotion programs under the flagship Wood Europe Campaign during the mid 2000's. Public policy promotion was directed to town and community planning to enhance wood frame construction. Wood Construction Development programme (WCD) 2004-2010 and parallel Wood Product Industry Business and Entrepreneurship (WPIBE) programme 2004-2010 constituted a joint attempt to adopt a) value chain approach into public innovation policy on wood construction & products and b) to allow real estate & construction cluster boundary crossings. WCD had uban & suburban residential area town plan approach and one-family house solutions in program focus. These were supported by the targets of a) knowledge enhancement, financing reorientation and international competitiveness (Figure 6) .

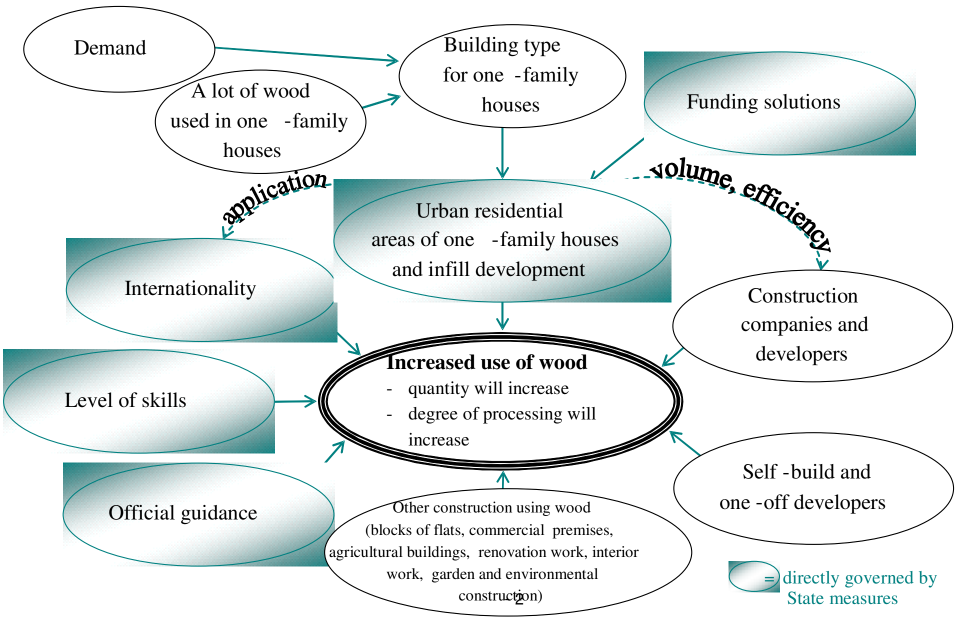


FIGURE 6 Wood Construction Development Programme 2004 – 2010: sturcture & objectives. Figure by the courtesy of Merja Laitinen -The Housing Finance and Development Centre of Finland (ARA)

## Future - Towards Sustainable Development in European Wood Construction

There have been increasing public policy interests to enhance the use of wood modules and components in BtoB construction. European enhanced construction wood use programs have launched cross sectoral program initials. Snow 2005 summarizes the main issues in rethinking construction in the opening conference of the international research and development project (GATE - Building New Opportunities for Timber) by a) promoting coordinated national activities towards programmed rethinking & re-engineering of construction processes. but also innovation projects beyond the existing cluster interfaces, b) reorganizing contracting by substituting the lowest price mode with whole life cost criteria as the contracting base & performance measures for evaluation and c) supporting best practice dissemination by approved purposes, progress and commitment to start constructing differently and in a sustainable ways. http://www.gate-project.org/index_en

**Wood Construction - Living Business Competence Cluster Programme**

The Centre of Expertise (CofE) programme executors in the Ministry of Interior accepted “Living Business” knowledge & competence enhancement cross cluster program as one of the themes of expertise in the second Centre of Expertise programme (OSKE II) in 1997. CofE is a fixed term governmental programme umbrella for 2007-2013 representing the view of Vanhanen I Government to improve regional competitiveness in line with the national and European policies. Living and housing, constituting the core themes of the program, are expected to be transformed from products into services. This shift implies house construction to be developed towards user-orientated living solutions and services. The purpose is to generate a new way of thinking and operate. The business of living shall promote the shift from a production-based operational model to a user-based supply of housing, products and services. CofE programme challenges regional actors into the joint interest cross cluster networks. Single projects, to be established within the Living Business programme, aim at developing and piloting product and service solutions for living and housing in genuine user environments. The aimed areas of application include urban living, solutions for special needs housing and senior citizens’ housing in particular, as well as energy-efficient and environmentally friendly construction and living.

## Concluding Remarks

Construction element prefabrication has long historical perspective in wooden house industries in Scandinavia with parallel national development features. Wood Construction Element prefabrication started as BtoC detached house components and modules business as a part of urbanization in extensive volumes from the1950s. Standardized booths and barracks were produced by some enterprises both in Sweden and Finland. The latter products, supplied into BtoB demand segments, had exterior characterized by the volume element technique. These component and module products covered also integrated solutions and were supplied as volume element products. Factory product development progressed from simple products towards higher amount of customization and flexibility, without abandoning high degree standardization (see Kouti 1965 and Höök 2008). Wooden house industries faced with strategy reorientation in the 1990s: in Sweden from 1995, when the Swedish building codes were changed and in Finland from the early 1990s on due to the radical demand decrease in the economic recession. Wooden house manufacturers became more clearly specialized into two different subgroups. Some firms continued producing for BtoB demand segments focusing either on commercial buildings (schools, office-buildings) or in Sweden also the market of multi-storey housing. Majority of the firms focused producing detached houses for BtoC demand segments.

Wood construction element prefabrication for BtoB demand segments imply value chain specific managerial skills in real estate & construction cluster. Functional specialization strategies are the major prerequisites among the wooden house manufacturers to become competitive in BtoB construction value chains. Partnering in those value chains imply modularity process arrangement solutions adaptable into the system and architecture information structures. Innovations in BtoB construction system context imply a) common vision shared by the majority of the players in the system & abilities to communicate currently in BIM information infrastructure, b) common commitment to the direction and co-ordination of resources covering also ICT solutions applied in AEC / FM systems and c) new and innovative material and mental resources (Brege et.al. 2005). Wood product industries are among the key actors to co-ordinate the business inside the value-adding wood product chains. Development challenges have clearly been identified in a research survey concerning Sweden (Brege et.al. 2005). The challenges in co-ordination have been clearly noted in earlier Swedish programmes where the co-operation between players was noticed to be fair or non existent (VINNOVA Branschforskningsprogram för skogs- och träindustrin. http://www.vinnova.se)

The challenges related to value chain architectural innovations are limited when compared with those in system innovations. The identification of the decoupling points and specifications there are important for all partners (see figure). The upflow and downflow challenges related to wooden house and joinery industry are discussed earlier. The major challenges concern the decoupling points between the clusters ie. wood products and real estate & construction respectively. Modular innovations and development are carried out under the conditions of system specifications and those in the decoupling interfaces (see Björnfot 2006 and Höök 2008).

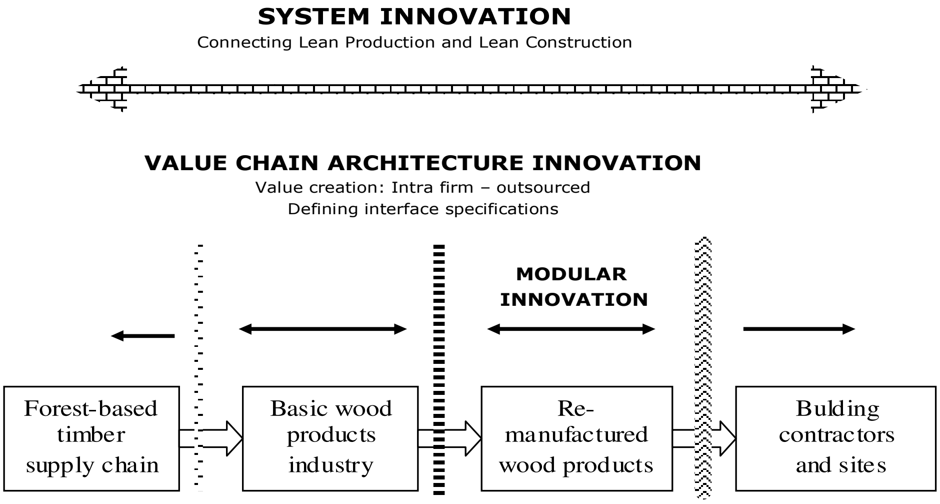


FIGURE 6 Innovation categories: system, value chain architecture, modular-
- wood product value chain (Ollonqvist. 2006)

Innovations in the business networks are the major challenges what concerns development of lean principles in wooden house and joinery industries and construction enterprises respectively. The recent SWOT analysis in Sweden could identify weaknesses when construction wood component and module are concerned 1) the production orientation in the business management of sawmills, their lack of customer added value orientation and technology push innovation patterns and 2) missing innovation system supporting BtoB constriction in wooden house and joinery industries, their low value chain development orientation and high competition boosted by fragmented demand and supply (Brege et.al. 2005).
The use of new technologies implies newly formulated management & organizational solutions and also new approaches on the customer interface in addition to new products or production processes,. Global business logics have challenged the role of managerial knowledge in business networks and imply strong public support resources into organizational (network management, utilization of cluster co operation) and marketing (customer orientation, product life cycle management, global business) innovation processes.

Author's presentations in SSFE meetings are referred to:

Forestry and Forest Based Entrepreneurship & Innovations in Rural Development Context – Finland.

Forest policy workshop of Scandinavian Society of Forest economics (SSFE) 14.8.2007 Saariselkä, FINLAND

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# Competitiveness of Whole-Tree Bundling in Early Thinnings

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## Abstract

In 2007, the first prototype of the Fixteri bundle harvester capable of incorporating whole-tree compaction into the cutting phase was launched by Biotukki Oy. The bundles are hauled by a standard forwarder to the roadside storage, from where pulpwood bundles are transported by a standard timber truck to the end-use facility. At the puplmill, bundle batches are fed into a wood flow consisting of conventional delimbed pulpwood. Separation of the pulp and energy fractions does not take place until the wood reaches the debarking drum. Energy wood bundles are crushed and used for energy generation. In the pre-feasibility study carried out by Metsäteho Oy and the Finnish Forest Research Institute, the required performance level of bundle harvesting (i.e. cutting and bundling) of Scots pine (*Pinus sylvestris* L.) dominated stands was determined by comparing the total supply chain costs with most common pulpwood and energy wood supply chains. The system analysis showed that whole-tree bundling enables the reduction of procurement costs below the current cost level of separate pulpwood and energy wood procurement in early thinnings. The greatest cost-saving potential lies in small-diameter ($d_{1.3}$ = 7–10 cm) first-thinning stands.

**Keywords:** Costs, Bundling, Integration, Small-diameter wood, Pulpwood, Energy wood, Early thinnings.

## 1. Background

In Finland, wood production, especially the production of saw and veneer logs, is based on thinnings. Usually two or three commercial thinnings take place before the final cutting. According to the National Forest Programme, the annual need for first thinnings is 250,000 hectares

(Anon. 1999). During the 2000's, however, only 167,000–206,000 hectares have been thinned annually (Juntunen & Herrala-Ylinen 2007, 2008). Consequently, the total area of delayed first thinnings amounts to 600,000 hectares (Korhonen et al. 2007). Based on the latest forest inventories (Korhonen et al. 2007), the target for first thinnings should be increased up to 300,000 hectares per year during the next ten years.

In 2007, 3.0 million $m^3$ (solid) (6.1 TWh) of forest chips were used in Finland (Ylitalo 2008). Of this amount, 87% was used by energy plants and the remaining portion by small-sized dwellings (Ylitalo 2008). Only one quarter (1.4 TWh) of the commercial forest chips were produced from small-sized trees harvested from early thinnings (Ylitalo 2008). The annual use of forest chips for energy generation is to be increased to 5 million $m^3$ by 2010, and by 2015 up to 8–12 million $m^3$ (Anon. 1999, 2003, 2008). Therefore, the harvesting of small-diameter ($d_{1.3}$ <10 cm) wood from young stands must increased three- or even fourfold, compared to the current volumes.

High harvesting costs, resulting from small stem size, low removals and dense undergrowth, is the main problem when harvesting both energy wood and pulpwood from thinnings (e.g. Kärhä et al. 2004, 2005, Kärhä 2006, Laitila 2008, Oikari et al. 2008). In order to increase the volumes harvested from young stands, the harvesting costs have to be significantly reduced (e.g. Kärhä 2007a, Kärhä et al. 2007).

There are several options to combine the procurement of industrial roundwood and energy wood. The integration aims at lower total supply chain costs than in the case of separate procurement of roundwood and energy wood. In Finland, the production of logging residue chips from final fellings is strongly integrated with industrial roundwood procurement. Logging residues are stacked into piles on the felling site by the harvester, and to a certain degree, the same machinery is used for the forest haulage slash and industrial roundwood (Kärhä 2007b).

With regard to first thinnings, integrating the procurement of energy wood into that of pulpwood has been attempted on several occasions during the past decades. For example, separating whole-tree chips into pulpwood and energy wood fractions was tested with the Massahake method (Ahonen & Viinikainen 1993), and the flail delimbing method for debarking and chipping of whole trees (Hakkila & Kalaja 1993). These integration systems designed for first thinnings did not, however, achieve the same success as those of final fellings. In particular, no cost-effective methods for long road transportation distances have so far been found (Kärhä et al. 2007).

## 2. A novel technology for young stands

Compacting logging residues into cylindrical bundles was a breakthrough, which enabled cost-efficient operation in the case of extended forest haulage and long-distance transportation (Asikainen et al. 2001, Kärhä et al. 2004, Kärhä & Vartiamäki 2006). Transferring bundling technology into thinnings was only recently considered a complex technological and economic problem, to which there is not a solution in a view (Hakkila 2004). Three years ago, however, forest machine entrepreneur Pasi Romo from Biotukki Oy (www.biotukki.fi) constructed the first prototype of the Fixteri whole-tree bundler capable of cutting and bundling of small-diameter tree in dense thinning stands. The bundles produced by the bundler are approximately 0.5 $m^3$ in solid volume. The weight of the bundling unit is about 5.5 tonnes. The first bundler was mounted on the rear end of a Valmet 801 Combi harwarder, but it can also be installed onto other base machines.

The work cycle of a harwarder-based whole-tree bundler is as follows:

- The trees are felled and accumulated into bundles with an accumulating harvester head. Thereafter, the bunch of whole trees is lifted onto the feeding table of the bundler (Fig. 1).
- The feeding rolls pull the stems into the feeding chamber of the bundling unit.
- The stems fed into the feeding chamber are cut to a length of 2.6 metres with a chain saw installed at the chamber gate.
- The stems sections are lifted from the feeding chamber into intermediate storage above.
- A sensor detects the amount of wood in the intermediate storage, in which the trees are compacted. When the storage is full, the bundle is lifted into the compressing chamber above for the final compaction and wrapping with sisal string (Fig. 2).
- After wrapping, the bundle is dropped down along the strip road (Fig. 3).

Except for placing bunches onto the feeding table, the bundling process is autonomous, enabling simultaneous cutting and accumulation of subsequent bunches.


**Figure 1.** The first prototype of the Fixteri whole-tree bundler taking wood onto the feeding system of the bundler. Photos: Metsäteho Oy / Kalle Kärhä.


**Figure 2.** The accumulated bundle is lifted into the compressing chamber, in which it is compressed and wrapped using sisal string.


**Figure 3.** The compressed and wrapped bundle is dropped along the strip road.

In addition to bundles with pulpwood-dimensioned trees, separate energy wood bundles composing of undersized trees and undesirable tree species can be produced (Fig. 4). The bundles are hauled by standard forwarder to roadside storage, from where pulpwood bundles are transported by standard timber truck to the pulp mill (Fig. 5). Separation of the pulpwood and energy wood fractions takes place in the debarking drum. The pulpwood bundles are fed into the debarking process as blends with conventional delimbed pulpwood harvested from first thinnings. Bundles containing only energy wood are delivered to the heating and power plant for energy generation (Fig. 5).

**Figure 4.** Pulpwood bundle (left) and energy wood bundle.


**Figure 5.** The whole-tree bundling system.

The results from whole-tree bundling experiments indicate that the machine concept is viable in terms of its basic technical solutions (Jylhä & Laitila 2007). Furthermore, encouraging results from debarking and pulping of bundled Scots pine (*Pinus sylvestris* L.) sections harvested from first thinning have been obtained (Jylhä & Keskinen 2006).

## 3. Pre-feasibility study

Competitiveness of the bundling system was evaluated based on a system analysis, in which the total supply chain costs of the following procurement chains were compared:

- Separate procurement of pulpwood (cutting with single trees)
- Separate procurement of energy wood (whole-tree chips):
  - Roadside chipping
  - Chipping at plant
- Integrated procurement of pulpwood and energy wood:
  - Whole-tree bundling
  - Loose whole trees.

The cost calculations indicated that whole-tree bundling enables undercutting the current costs of the separate procurement of industrial pulpwood and energy wood from first-thinning stands (Fig. 6). The greatest cost-saving potential lies in small-diameter ($d_{1.3}$ = 7–10 cm) first-thinning stands, which are currently relatively unprofitable sites when applying conventional procurement systems with separate pulpwood harvesting applying single-tree harvesting.

The productivity of the bundle harvester, however, will have to be raised well above 50% of that of conventional feller-buncher (Fig. 6). This means, for example, that the performance of bundle harvesting must exceed 4.6 $m^3$ (9.2 bundles) per effective hour ($E_0$, excluding delays) with bundle size of 0.5 $m^3$, when the breast height diameter (DBH) of the trees to be removed is 7 cm. In the case of trees with DBHs of 11 and 13 cm, the productivities must exceed 7.6 and 8.7 $m^3/E_0$-hour (15.1 and 17.4 bundles/$E_0$-h), respectively.

Cost savings with the procurement system based on whole-tree bundling can be achieved especially in the case of relatively long forest haulage and road transportation distances. When whole-tree bundling is applied to the harvesting of energy wood ($d_{1.3}$ <7 cm) only, significant cost savings are not achieved (Fig. 6).

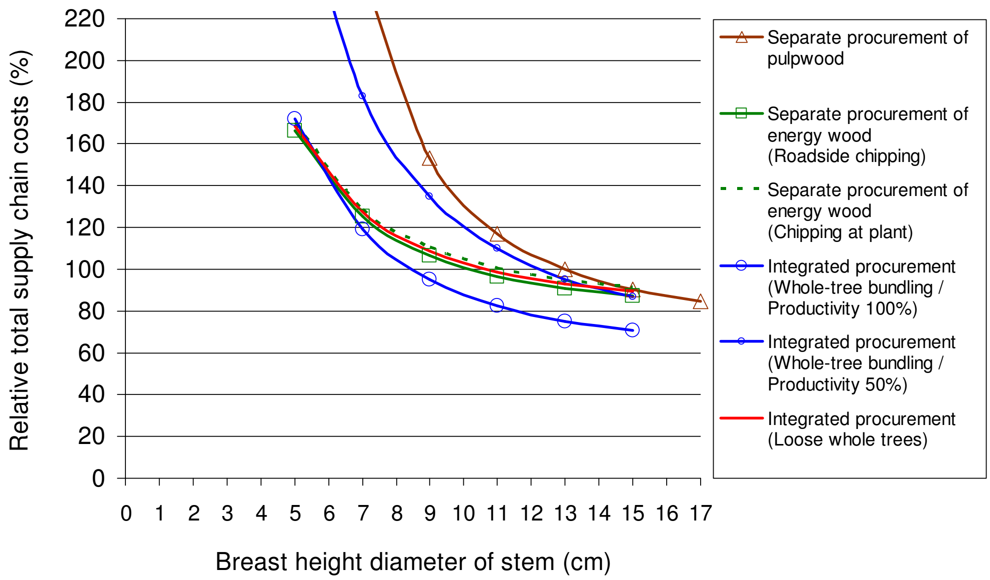


**Figure 6.** Relative total supply chain costs of wood harvested in early thinnings as a function of stem size. Calculations were made assuming two (100% and 50%) productivity levels for whole-tree bundling compared to feller-buncher. Forest haulage distance was 250 m and road transportation distance 100 km.

## 4. Further development work required

The low engine power of the four-cylinder harwarder used as a base machine, as well as the lack of grapple feeding system, were the main causal agents for the relatively low performance of the first prototype of bundle-harvester. Bundling unit in itself did not limit production (Jylhä & Laitila 2007). Along with improved interaction between felling and bundling processes, quicker functions, and improved working techniques, competitive productivity levels can be achieved. These bottlenecks were eliminated from the second version of the bundle-harvester, which is currently being tested.

With the felling heads (Naarva-Grip 1500-40E, Nisula 280E) tested with the first prototype, it was necessary to lay the felled wood bunch on the ground and to take a new grip before feeding it into the bundling unit. Despite these improvements, the purchase price and operating costs of the base machine of bundler should be kept at reasonable level.

Metsäteho Oy and the Finnish Forest Research Institute will carry out further time studies and economic analyses on the whole-tree bundling system in 2008–2009. The R&D project is funded by the National Technology Agency (Tekes) and the Finnish forest industries.

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# Economic Effects of Russian Customs Programme for Roundwood Exports on Eastern Finland and the Republic of Karelia

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**Abstract**

Using input-output –method, this study evaluates income and employment effects of Russian customs programme for roundwood exports on both the wood working and the pulp and paper industry in Eastern Finland. In 2006, the shares of domestic and imported roundwood of the total wood use in Eastern Finland were 58 and 42 percent, respectively. Four different scenarios of roundwood import reduction and two different possibilities to increase domestic roundwood procurement were analysed. Due to lack of data, similar effects for the Republic of Karelia were calculated using two alternative scenarios to compensate reducing exports.

The results indicate that forest industry, together with multiplier effects on other sectors, in Eastern Finland is facing considerable structural changes if the custom tariffs programme for roundwood exports from Russia is fulfilled. The key issue for the development of employment and incomes in Eastern Finland's forest industry is how the domestic wood procurement or roundwood imports from other countries can be increased to compensate the Russian roundwood imports. In the worst scenario with only limited possibilities to increase domestic wood procurement, unemployment will increase nearly six thousand and value of production will decrease even by two milliard euros. Even if domestic wood procurement can compensate the reducing roundwood export amounts to some extent, the employment will decrease by few hundreds of employees and the loss in production value will be in the range of tens of thousands millions to over one hundred million euros. The corresponding results for the Republic of Karelia due to the decreasing roundwood exports indicate also considerable increasing unemployment and decreasing value of output in regional economy, if the domestic production capacity especially in mechanical wood working industry is not able to increase production volumes. The unrealistic scenario, where mechanical wood working industry is able to double its production, results neutral effects.

# Architects', and Building Engineers', and Stakeholders' Perceptions to Wood in Construction – Results from a Qualitative study

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## Abstract

The study presents information about Swedish engineers' and architects' main considerations in material selection. It describes the material selection process, including perceptions of wood compared to other materials, the influences of main stakeholders, and how wood construction relates to professional roles and career prospects. Issues related to knowledge about wood as a material, the position wood construction has in the Swedish education and recent developments in wood-based construction techniques are also highlighted. Finally, we present the needs architects and engineers have of wood suppliers. Our results are translated in a number of improvements to increase wood as a construction material in large-scale construction.

**Keywords**: wood-frame building, attitudes, stakeholders

## Introduction

In Sweden, wood frame construction techniques dominate single-family housing, whereas concrete is the most common material for multi-story housing (Bengtson 2003). In January 1995, restrictions for building multi-story wood-frame houses in Sweden were replaced by criteria for functional performance. Consequently, the wood industry expected a promising new market in the construction sector (Nord 2005). A governmental investigation (Anon. 2004) concluded an increased use of wood in construction is desirable for the industry and environmental reasons. Wood has good environmental credentials with regard to energy savings and carbon sequestration (Upton et al. 2008, Gustavsson et al. 2006). And, new alternatives for construction would increase competition in the building sector and lower prices. Therefore, a programme for promoting wood-frame is currently underway. Wood-frame construction is also promoted at the European level. However, the expansion of wood frame building has not become a natural method for multi-story construction in Sweden or in Europe (Nord 2005).

Current construction technical requirements focus on function and safety. Construction must also comply with local building regulations, which address zoning, maintaining historic and cultural traditions, and environmental requirements. Yet, to an increasing degree, building practices are formed by European directives and committee work on wooden constructions. Stricter norms on energy saving capacity of buildings have recently been introduced in Sweden.

Much R&D work on wood frame building has been focussed on technical issues. Since wood frame building is essentially a cultural change, topics referring to attitudes, traditions, culture and the professional roles merit further studies.

Architects and structural engineers are two key groups that together affect material selection in construction. Knowledge about the perceptions, beliefs, influence and knowledge that these professions have towards wood in construction would provide valuable input for the wood industry. Such input could form the basis for improved offerings as well as gaining the confidence of key advocates in the material selection process.

The purpose of this study was to assess Swedish building engineers' and architects' perceptions on wood in construction. We also examine their role in relation to the different stakeholders in the decision process. The study is limited to multi-story residential buildings and larger projects such as schools, institutional buildings, and commercial buildings.

## Previous studies on perceptions on wood frame

Recently, a number of researchers have studied the implementation process of new wood-frame approaches in the Swedish building sector. Bengtson (2003) explained concrete's dominance as a combination of different contextual factors and industrial networks. Bergström (2004) and Sardén (2005) studied pilot projects that introduced timber structures on project level. Their results confirmed the importance of integration and information sharing between the actors in the value chain and reasonable balance between customer focus and efficiency. Nord (2005) inferred that large Swedish sawmilling companies can be grouped into different waves of suppliers and partners for industrialized wood-frame building in Sweden.

In the USA, Kozak and Cohen (1999) claimed that the wood industry lack the resources and competence to market wood as a building material to architects and engineers. O'Connor et al. (2004) identified barriers among North American architects and structural engineers for an increased use of wood in non-residential construction: fire codes, costs, design difficulty, and poor training among designers and trade people. Similar results were acquired in an Australian study (Bayne and Taylor

2006). The authors explained the low degree of adoption by designers/specifies of timber structures in non-residential buildings by fire performance concerns and an overall lack of designer confidence, lack of knowledge in timber design, and lack of marketing by the wood industry.

## Research approach

The Theory of Planned Behaviour (Ajzen 1991) was used as a conceptual framework for our enquiry about wood framed construction. Our applied interpretation raises three main considerations which influence professional's intentions to either suggest or support wood-frame in building projects. Firstly, *Attitudes about the perceptions of* wood, particularly whether they regard wood as a reliable, appropriate, high performance building material. Secondly, *Subjective Norms*: a professional's anticipation of the normative reactions of others, particularly whether experience of wood frame building entails professional respect or is likely to lead to the commission of new projects. *Control beliefs*, which cover perceived factors that facilitate or hamper the proposal to have wood in the construction, i.e. knowledge about wood construction, or perceived problems implementing wood in the industrial network.

Since perceptions and beliefs were theoretically important, and the work had an explorative character, a standard qualitative analysis was chosen (Silverman 2001, Miles and Huberman 1994). Respondents were purposively selected to constitute a diversity regarding gender, role in the decision process, and wood building experience. In total 23 people were interviewed. The interviews were conducted, mainly face-to-face in 2007, and transcribed. These were analysed using a coding procedure (Miles and Huberman 1994), where researchers separately coded the same text and then discussed the various coding outcomes to reach a negotiated consensus on coding principles.

## Results

### Factors influencing material selection

Respondents considered an important factor that influenced material selection in multi story buildings and larger constructions was dominating ***standard practices*** in construction. That is, the most applied and practiced building methods for constructing a particular type of house. Respondents in the largest companies were also particularly constrained by ***corporate policies*** that advocated 'platforms' and prescribed materials. A related factor was the ***availability of good examples*** showing that a material and building technology works. Architects frequently use such examples for inspiration and models in their planning. Structural engineers preferred to use existing building examples, since it verified a construction method worked in practice. "*It is never good to be number one – it is better to be number two when it comes to applying something new (high rise wood frame)"* (engineer).

Another consideration that mostly architects raised was that the new building should harmonize with its ***built and natural environment.*** This also included ***local building traditions,*** which tended to support the use of wood in rural areas and in Northern Sweden."*In rural settings, wood is the natural choice in the Nordic countries – This is our cultural background"* (architect). ***Aesthetic*** aspects also referred mainly to visible surfaces.

Most respondents considered that the regulatory changes in 1994/95 meant that **c*odes, regulations and authority decisions*** were of minor importance in material selection. Nonetheless, the influence of these factors on building norms, and local historic considerations in urban areas could still influence material selection outcomes. Similarly, the impact of ***physical requirements of the frame*** on material selection depended on the function, building details and ground conditions.

Respondents also assumed that ***energy efficiency*** and ***environmenta***l arguments would increasingly exert an influence on material selection.

***Economic and cost considerations*** were stated as an important factor. However, the issues weighted in such calculations differed from project to project. Key costs parameters ranged from construction costs, maintenance costs, life cycle costs, construction time, risk considerations etc. However, a frequent phrasing was, *"The budget must be respected"*

### Wood's relative merits in construction

***Fire properties*** were still frequently mentioned as obstacles for wood in construction by many respondents. Others pointed out that massive wood structures have an advantage since these have a predictable reaction to fire (pyrolysis), where total collapse is less likely than for steel.

***Sound transmission properties*** were a serious technical obstacle to wood, since concrete required less space to solve sound transmission problems.

***Form stability*** and movements were also stated as drawback for wood. Form stability was often associated with ***moisture content*** issues, which can also lead to mould, and unhealthy dwellings. However, some respondents claimed that moisture issues could easily be handled with the building techniques. Other respondents perceived a ***higher risk*** when building in wood, and consequently higher costs. Wood was also seen as more difficult to pre-calculate.

Woods' variability and biological origin lead to some respondents considering it as ***insecure supply***. Engineers in the construction industry complained about fluctuating prices and had a feeling that producers gave priority to export markets, at the expense of long term business relations in

Sweden. Further, the ***fragmented wood industry*** was reported to constitute an obstacle for sufficient ***support*** of architects, engineers and builders.

According to our respondents, woods' ***light weight*** saves energy in and money in the construction phase. They also stated wood is more appropriate for industrialised building methods because larger building components can be prepared in the factory, in dry conditions, and then transported to the building site. Some building engineers said woods' strength to weight ratio was an additional argument in favour of wood. However, it was also acknowledged that wood was not as suitable for large ***span lengths*** as concrete. *"Wood is not appropriate for very large industrial buildings. But glulam is very suitable for large warehouses and hall"* (engineer). Wood as a building material was also characterized as ***flexible,*** enabling design opportunities and changes during and after the building process.

In visible applications wood is often claimed to have an ***aesthetic*** advantage because of its natural, warm and human appearance. It also is said to create a ***pleasant indoor climate*** and ***atmosphere***. However, visible wood requires ***maintenance*** so the surface retains its appearance.

Views on ***cost advantages*** varied. Several respondents affirmed that wood can be cost-competitive, because of its light weight and opportunities for industrialised building methods. However, one entrepreneur/contractor stated that on-site construction of wood can become prohibitively expensive due to the man hours involved. Lack of experience in using wood gave rise to feelings of insecurity, which are calculated to add costs to a project.

Wood was also considered to have ***environmental and climate advantages*** since it assimilates and stores carbon, has good insulating properties and requires less energy for transport and construction. Large builders were reported to have an environmental policy, although few could describe its main content or whether it would influence the material selection. *"They do not prescribe specific materials – rather, they pose environmental criteria on the materials that are being used"* (engineer).

### The decision process

The actor in the process with the largest control over the material selection was the ***commissioner*** of the process. *"The developer must prefer wood – otherwise it won't be wood" (architect).* Local housing firms were reported as tending to prefer concrete since they perceived concrete as longer lasting, with little maintenance requirements. However, low costs and fast assembly of wooden constructions may lead to some developers adopting the view that wood out competes concrete in some cases.

In Sweden, ***builders*** can be segmented according to whether they work in large corporations with operations throughout the country, SME:s which are often regionally based, or micro enterprises. Several respondents viewed the large builders as very influential actors in the concrete tradition." *The developer and the builder – it's mainly their decision (architect).*" Nonetheless, respondents informed that a few smaller builders had more favourable approaches to new technology, with some even specialising in wood construction. Builders can also play two roles in construction: acting as a commissioner, including selecting a parcel for construction of apartments, also acting as a constructor to build the properties; and, finally, acting as an entrepreneur and selling the properties to a housing cooperative. ***Architects*** were curious about wood and the use of wood as a structural element, however they had a limited authority." Swedish architects have a weak influence compared to other countries (architect)." Their possibility it influence increases with experience and reputation. And, there was also an opportunity to support wood-frame in smaller projects outside the largest cities.

The ***structural engineer*** normally took responsibility for the structural aspects of the project." *Architects can influence the visible parts – the engineer influences the frame" (engineer).* Several respondents perceived this category mainly favoured concrete, often indirectly influencing decisions by displaying unease about the possible use of wood.

As implementing bodies of zoning and local building regulations, ***local authorities*** have an impact mainly on façade materials. One local municipal commissioner had received instructions to always include one wood frame alternative when evaluating all new housing projects.

Respondents working in the construction sector frequently complained that ***wood material suppliers*** were rather anonymous and passive in their marketing of wood products. People in the building sector wanted more product and systems innovation, support and active, personnel marketing. Wood suppliers' current marketing efforts did not match those of other material providers.

***End-users*** can rent apartments, which is more common in Sweden than many other countries. End-users can also be cooperative owners of a house, where ownership is jointly held by all dwellers and shares are allocated to individual owners on the basis of apartment standard and size. End-user preferences were not expected to tend towards any specific structural material. Some interviewees even claimed that dwellers often were unaware of the structural material. Developers/builders of new cooperatives assumed that sound isolation preferences currently exclude wood structures on multi-storey buildings.

The process was dependent on the ***type of project*** and its ***contracting forms***. Large housing projects were often managed by a large builder, and main decisions implied by the policies of the enterprise. Smaller projects however could provide more power to the individual architect. The project could also be pre-specified by the developer (including material choice) or it could be open both for wood or concrete. The process could also be structured openly, with project development taking place when the parties moved in a stepwise fashion.

### Views on the most recent developments in wood construction

Based on our interview material, the most recent developments affecting wood building can be classified as institutional, organisational, industry and technical. The most pivotal ***institutional change*** was the removed restrictions on multi-story wood wood frame in 1994. Several respondents claimed that the new regulatory situation had not had a fundamental impact on wood frame's share of construction. Respondents also mentioned increased focus on energy savings. Local instructions to seriously consider wood frame building were other developments of this type mentioned by the interviewees. Research programmes to improve and adapt wood properties and technologies were also mentioned.

***Organizational changes*** included a network oriented towards educating and inspiring professional architects about wood architecture. Currently a wider promotion campaign is co-financed by the wood industry and the government. It features seminars, courses and demonstration projects.

An ***industrial change*** is the emergence of new actors adopting wood construction, who use with industrial methods. These can be wood industries advancing in the value chain, or contracting SME:s.

A number of ***technical and systems innovations*** have occurred. These involved sound insulation of wood materials, panel products, fire resistant materials, improved lumber quality, glulam, and engineered wood. In some cases, however, we were told that innovation projects had been inhibited prior or after market launch. Several persons described ***industrialized wood building methods*** as promising for several reasons: dry pre-fabrication increased quality, speed of on-site assembly, requiring less personnel on site.

Main actors driving the positive development towards innovative products and materials were innovative wood industries, mid-sized builders, and research institutes, whereas the four largest firms were considered to have chosen a inactive position.

### Professional role

Both architects and engineers thought it was interesting and challenging to work with wood. But it was more complicated and difficult because of woods' variability and moisture sensitivity. Some respondents considered these properties as essentially as wood's negative aspects, whereas others just saw them as an issue that could be solved with the right education and experience. Architects normally did not favour one material – it all depended on the vision and purpose of the project. However, as one responded said, some architects can be more focused on the material and what it can express. Architects and some engineers stated that the most salient attribute was woods' visual possibilities and some regretted that wood facades are often prohibited in large buildings.

Professional experience in wood frame building were not reported to improve possibilities to win new engagements.*"Wood experience doesn't improve my career" (architect).* What meant most for architects' prestige was winning competitions. The attitude among the most famous architects also mattered. *"When the "big names' engage in wood architecture – then it becomes interesting" (architect).* An annual wood architecture prize was for therefore highly valued. For engineers, professional reputation is often associated with experience of larger projects. One architect was dissatisfied by the modern wooden architecture of multi-story buildings.

**Knowledge**

Both professions considered their education had little content associated with wood construction. Furthermore, both architects and engineers though that architecture schools focused too much on design and very little on construction and physics.*"Students in Austria and Switzerland learn more about wood construction" (architect).* Structural engineers recalled wood construction was only taught in association with introductory smaller projects (detached house or carport), while concrete was seen as the only option in larger constructions. *"Concrete dominated during the later years in education" (engineer).*

It was also asserted that general knowledge of wood construction is weak throughout the building sector. One engineer also added that there is now much new wood construction know-how, although older experience-based knowledge necessary. *"We have forgotten much about wood construction during the concrete-era" (engineer).* While architects were claimed to lack general construction knowledge, engineers with thorough know-how in wood were scarce, thus creating a bottleneck for wood in construction. *"Architects often make mistakes in the small design details (engineer)" "It is disconcerting to hear an engineer say: Maybe it can be done in wood, but I don't know how" (architect)*

Although the increased importance of environmental performance was frequently emphasized, some respondents said it was warranted to request more data about environmental properties of different materials.

Frequently used information sources were on-the-job training, colleagues, professional journals and publications, internet, handbooks, software, courses and seminars, information from suppliers (more frequent from non-wood suppliers, though).

**Future prospects and desired improvements from suppliers**

Depending on cost, most respondents foresee a growth of wood frame building, driven by increasing environmental requirements. However, the main prerequisite for success was that wood frame could present even clearer cost savings than today compared to concrete. ”*The future of wood-building – it's all about the economy” (architect).*

However, this will also depend on whether wood-frame can improve in a number of areas:

- Wood frame must clearly demonstrate that it makes sound business sense compared with concrete and steel.
- Information flows from the construction industry to the wood sector and back needs to be open and function smoothly.
- Improved wood construction approaches should be provided via hassle free building systems.*”Supply systems that fit together – demonstrate intelligent solutions that permit flexible solutions and appropriate span-lengths” (architect).*
- Wood-frame should emphasize aesthetic and visual aspects, making more of its components visible and as a part of the architectural expression.
- Finally, wood-frame suppliers could provide more information about woods' environmental advantages.

## Conclusion

Our results can be translated in a number of improvements to increase wood in large-scale construction:

1. Identify the most important criteria for the material selection
2. Identify the market segments where wood is competitive
3. Create strategies to
    a. Enhance the scope of the wood curriculum in university education
    b. Choose appropriate ways (information material, personal contacts, courses) to reach practicing engineers and architects with appropriate information
    c. Tackle the common widespread misconceptions about wood
4. Make wood fashionable, attractive, and challenging for both professions
5. Above all: Address the desired improvements from architects and engineers for
    a. Systems solutions
    b. Support
    c. Information
6. Present objective environmental performance measures on wood

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# Consumer preferences for wood surfaces – a latent variable approach

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## Abstract

Only a few studies have been published examining consumer preferences for wooden surfaces (interior cladding). The purpose of the study was to develop and test measures for three four variables: preference, perceived harmony, reaction to complexity and perceived social status. For doing this, we used an experimental design where subjects were exposed to different sets of wooden surfaces. A total of 313 persons took part in our survey. Due to missing values, 35 questionnaires were discarded and we were left with 278 forms which amounted to 834 evaluations of wood surfaces. We estimated a revised measurement model. This study has concluded that preference for and perceived social status and perceived harmony of wood surfaces can be measured with satisfying reliability and validity. The study also found that several questions that have been used earlier had to be discarded as measures of the core constructs.

**Key-words:** Consumer preferences, wood products, indoor cladding, structural equation modeling, latent variables.

## Introduction

Only a few studies have been published examining consumer preferences for wood products (Marchal and Mothe 1994; Broman 2000a; Brandt and Shook 2005; Jonsson 2005; Nyrud, Roos and Rødbotten 2008). Knowledge about consumer perceptions and preferences for wood gives several benefits. By basing sawing, splitting, and sorting of wood on information about consumer preferences for wood and wood properties one should be better able to maximize the value of the wood. It may even give input to stand management and tending. Further, it may give input into how wood should be used and applied, for example in furniture, and interior and exterior decoration. Finally, information about consumer preferences and perceptions for wood products may give input to segmentation, market positioning, market communication and presentation of wood products.

Broman (1995a; 1995b; 1996; 2000a; 2000b; 2001) was among the first to study consumer preferences for wood surfaces. In one of his first studies he (1995a) concluded that consumers are not particularly proficient in judging specific wood properties, but they judge the wood surface based on a more general impression. Therefore, he developed, based on in-depth-interviews, a battery of 54 questions (semantic differentials) about how people perceive wood properties. Through his analyses he reduced this battery to between 10 and 15 questions which he suggested were most relevant (1995a; 1996; 2000a; 2001). Broman (2001) grouped these variables into three composite variables that sum up much of people's perceptions of wood surfaces: *acceptance*, *harmony* and *activity*. From his argumentation and way of summing the items for each composite variable, these composite variables can be regarded as *latent variables or factors*. Latent variables are representations of unidimensional concepts that are unobserved and not directly measured. Rather latent variables are variables that can only be measured indirectly through measures containing a certain degree of measurement error (Bollen, 1989). However, Broman (2000a; 2001) did not call these groups latent variables, and analytically, he did not treat them as such. To our knowledge, there have been no studies testing the validity and reliability of Broman's (2000a; 2001) questions as measures of the three latent variables.

It is hard to study consumer preferences and perceptions without invoking abstract concepts. A problem with abstract concepts is that they can typically be measured in many different alternative ways, each with considerable measurement error. An advantage of thinking in terms of latent variables is that one can use structural equation modeling to analytically separate the relationships between the concepts (that form latent variables) from the relationships between the concepts and their corresponding measures. The purpose of this study is therefore to define Broman's (2006) composite variables as latent variables, develop the measures further to better reflect the underlying latent variables, and use standard psychometric test procedures to evaluate if the measures are reliable and valid. In other words, we conduct a confirmatory factor analysis. We also propose a fourth latent variable: *perceived social status* of the product, and compare the wooden surfaces in terms of how they score for each of these latent variables.

## Definitions of the latent variables

We departure from Broman's (2001) work to define the latent variables. Broman (2001) termed his dependent composite variable *acceptance*. He did not define this variable, but it was calculated as the sum of three semantic differentials positioned closely to each other in loading plots from principal component analyses. The anchor points for these three semantic differentials were: like it/dislike it, beautiful/ugly, and nice/objectionable. In contrast to Broman we define the relevant concept to be *preference*, defined here as the degree to which the product gives utility by fulfilling the perceiver's needs. This means that an ordering of the products according to product ratings reveals the order of preference of each product.

Since Broman's (2001) work was largely based on grounded theory – by first conducting qualitative analyses (Broman, 1995b) to generate questions for his questionnaire and then test different versions of his questionnaire quantitatively (1995a; 1996; 2000a; 2001) – we choose also to rely on recent developments within psychology about what makes people experience aesthetic pleasure as reviewed by Reber, Schwarz & Winkielman (2004). According to their theory aesthetic experiences are functions of the perceiver's processing dynamics. Their core proposition is that the more fluently the perceiver can process an object, the more positive is his or her aesthetic response, that is, the evaluative judgment. With processing fluency they mean the ease with which perceivers identify the physical identity of the stimulus and the ease of mental operations regarding what the stimulus means and how it relates to semantic knowledge structures. Objects differ in terms of how fluently they can be processed by perceivers. Objects containing only small amounts of information, being symmetrical, or exhibiting contrast and clarity, can be processed more fluently than objects containing large amounts of information, being asymmetrical or exhibiting low contrast and clarity. The effect of processing fluency on evaluative judgments is mediated by a subjective affective reaction, meaning that processing fluency positively influence the affective reaction, which subsequently provide the perceiver with information to form a judgment (Reber et al., 2004).

The most important determinant of acceptance, and thus preference, according to Broman's (2001) exploratory data analyses, is *harmony*. He defined harmony as the degree to which the attributes of the surface fit together – or, conversely, the lack of mismatching attributes in the surface. We view this finding as consistent with Reber, Schwarz & Winkielman's (2004) theory. Wooden surfaces perceived by consumers as harmonious contain less information and exhibit stronger symmetry than less harmonious surfaces. Harmonious surfaces should therefore lead to a more fluent processing of the object, and subsequently lead to a better evaluation both in terms of preference and perceived social status. We term this variable *perceived harmony* and it should be an important latent variable describing a wood surface.

The third composite variable discussed by Broman (2001) was *activity*, defined as the overall blend of wood properties and indicated with items such as interesting/uninteresting, stimulating/boring, rich/empty, lively/-rigid, contrasty/indifferent, eventful/uneventful. It is difficult to see the connection here between Broman's (2001) definition and the measures. Several of the measures, in particular interesting/uninteresting, stimulating/boring, and eventful/uneventful, seem rather to describe parts of the perceiver's internal experience more than the wood itself. Based on Broman's (2001) grounded measures, we choose to label this variable as *reaction to complexity*, since this accommodates viewing these measures as both a result of the internal process of the perceiver as well as the overall all blend of wood properties. Complexity has earlier been defined as the product of the number of parts and the interaction between the parts (see e.g., Kaufmann, 1993; Simon, 1962). A wood surface may be viewed as more interesting, stimulating and eventful, for example, if the viewer perceives the surface as having many elements that interact and form patterns. This should especially be so if the viewer due to his or her history and knowledge has a predisposition to see and appreciate such patterns. Reaction to complexity may affect both expected processing fluency as well as actual processing fluency and thereby preference. According to Reber, Schwarz & Winkielman's (2004) the most beautiful objects are often in aesthetics viewed as being those that combine simplicity with complexity, when there is "uniformity in variety". How people perceive the complexity of the surface may thus be an important determinant for preference of the product.

Among the items that Broman (2001) weeded out from his battery of questions were several that related to the extent to which the product was perceived as expensive, exclusive or of high quality. We regard these questions as reflecting social status, which we define as the honor or prestige attached to the product in society. It is well known that people often consume in order to signal social status, not only in order benefit from the intrinsic value of the products in use, what Veblen termed conspicuous consumption (Mason, 1984). The extent to which the product is perceived as having a high social status should thus be a relevant variable.

## Research design and methods

### Experimental design

The purpose of the study was to develop and test the measures for preference, perceived harmony, reaction to complexity and perceived social status. For doing this, we used an experimental design where subjects were exposed to different sets of wooden surfaces. 10 different wooden surfaces were made and each subject was exposed to a random set of three surfaces. There are 120 different ways of combining three out of 10 surfaces. The subjects were asked to complete a short questionnaire with semantic differentials for evaluating the surfaces. The items measured preference, perceived harmony, reaction to complexity and perceived social status for each of the three surfaces. This design meant that we received three observations per informant (3 surfaces per informant), so that the dataset constituted a panel data set. The final experiment (after pilot study and pre-test) was conducted at a hobby and home improvement fair, a location at which it should be possible to recruit many informants. The informants were recruited as they passed along our stand. The questionnaire took between 5 and 15 minutes to complete, depending on the speed of the informant. There were also other questions on the questionnaire.

### Wood surfaces

The 10 wood surfaces were all indoor cladding surfaces of Scots pine (*Pinus sylvestris*), with varying degrees of presence of physical attributes (e.g., fresh knots, dry knots, bark ring knots, black knots, leaf-shaped knots, resin pockets, heart wood, tension wood, and different growth ring patterns). The surfaces covered a wide range from clear wood to many attributes mixed in different ways. To the extent possible, the surfaces corresponded to different grades described by the Nordic Wood Standards. The surfaces were all made the same way following a common indoor pine cladding design in Norway. Each surface was composed of 5 boards, each 195 cm tall and 120 mm broad. The boards were separated by a 10 mm broad beveled slit. The surfaces are exhibited in figure 1 and table 1 provides basic descriptive data about each surface. As at the hobby and home improvement fair, the surfaces are presented against a black background. Whether a knot should be judged as fresh, or having some sort of "defect", such as bark ring or being black, is to some extent a matter of judgment. It should therefore be noted that the measurements reported in table 1 are the result of one person's judgment only.

**Measure development**

Before conducting the final experiment and testing our measures we conducted a pilot study and a pretest. The pilot study involved using Broman's (2001) measures and translating them from English to Norwegian as well as testing the measures on six employees in our own university department. All these persons are wood technologists. Their feedback led to several adjustments in the questionnaire. The questionnaire was also discussed with a food scientist experienced with preference studies of food. This also led to re-formulations. The pretest involved testing the measures on responses from 18 random persons. This gave 54 observations (3 surfaces per person), enough to test the measurement model statistically. Two of the items worked particularly bad and were reformulated or replaced. The first problematic item was Broman's (2001) ugly/beautiful item, which did not load highly on preference. This item was therefore replaced with another item. The second problematic item was Broman's (2001) hard to look at/easy to look at. This was replaced with exhausting to look at/comfortable to look at, which Norwegian translation (slitsomt å se på/behagelig å se på) worked well.

**Table 1:** Overview of core properties of the surfaces

| Surface # | Nordic Wood grade | Description | Number of *fresh* knots | Mean size of *fresh* knots ($cm^2$) | Area *fresh* knots ($cm^2$) | Number of *non-fresh* knots | Mean size of *non-fresh knots* ($cm^2$) | Area of *non-fresh knots* ($cm^2$) | St. dev. of knot sizes | Mean breadth growth rings | St. dev. of growth rings |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | A | Clearwood, uniform growthrings | 0 | - | 0 | 0 | - | 0 | 0.0 | 3.8 | 0.7 |
| 2 | A | Clearwood, non-uniform growthrings | 0 | - | 0 | 1 | 0.0 | 0 | 0.0 | 5.0 | 2.2 |
| 3 | A4 | Few small fresh knots | 21 | 1.6 | 33 | 6 | 1.3 | 8 | 1.2 | 2.9 | 0.4 |
| 4 | B | Some small fresh knots | 41 | 2.0 | 84 | 6 | 4.9 | 30 | 2.5 | 3.1 | 0.3 |
| 5 | B | Some large fresh knots | 40 | 3.6 | 145 | 5 | 4.9 | 25 | 2.5 | 4.3 | 0.7 |
| 6 | B | Many large fresh knots | 52 | 3.6 | 185 | 14 | 0.3 | 5 | 4.1 | 3.5 | 0.8 |
| 7 | B | Many fresh knots and non-fresh knots | 54 | 2.3 | 126 | 34 | 2.0 | 69 | 2.2 | 2.1 | 0.5 |
| 8 | B | Assymetrical (2.5 boards clearwood) | 13 | 1.9 | 24 | 16 | 1.3 | 20 | 2.3 | 3.9 | 1.7 |
| 9 | B | Assymetrical (1 board clearwood) | 41 | 3.2 | 131 | 12 | 0.8 | 9 | 2.8 | 4.1 | 1.8 |
| 10 | C | Many non-fresh knots, including knot holes | 20 | 1.7 | 35 | 55 | 1.4 | 77 | 1.5 | 3.0 | 1.9 |

## Measures and proposed measurement model

All items were measured as Broman (2000a) with semantic differentials on a range from 1 to 7 anchored by bipolar words or formulations. These formulations are presented in table 2 together with Broman's (2001)

**Figure 1:** Overview of the surfaces. Number referrers to surface # in table 1.

original items. As can be seen, there are some differences. The *preference* items were introduced by the following question: Do you like the cladding? The *perceived social status* items were introduced by the following question: What is your impression of the cladding? *The perceived harmony*

**Table 2:** Overview of measures

| Latent variable | Item name | Our formulations | | Broman's formulations | |
|---|---|---|---|---|---|
| | | Low anchor | High anchor | Low anchor | High anchor |
| **Preference** | | | | | |
| | Like | Dislike | Like | Dislike it | Like it |
| | Want | Would not have used myself | Would like to use myself | Ugly | Beautiful |
| | Recommend | Does not recommend to others | Willing to recommend to others | Objectionable | Nice |
| **Perceived social status** | | | | | |
| | Quality | Low quality | High quality | Of low quality | Of high quality |
| | Expensive | Cheap | Expensive | Cheap | Expensive |
| | Exclusive | Common | Exclusive | Common | Uncommon |
| | Fashionable | Out of fashion | Fashionable | | |
| **Perceived harmony** | | | | | |
| | Harmonious | Disharmonious | Harmonious | Disharmonious | Harmonious |
| | Comfortable | Exhausting to look at | Comfortable to look at | Gaudy | Strict |
| | Restful | Restless | Restful | Restless | Restful |
| | Balanced | Unbalanced | Balanced | Unbalanced | Unbalanced |
| **Reaction to complexity** | | | | | |
| | Stimulating | Stimulating | Boring | Stimulating | Boring |
| | Interesting | Interesting | Uninteresting | Interesting | Uninteresting |
| | Imaginative | Imaginative | Unimaginative | Rich | Empty |
| | Experience | Rich in experiences | Poor in experiences | Eventful | Uneventful |
| | | | | Contrasty | Indifferent |
| | | | | Lively | Rigid |

and *reaction to complexity* items were introduced by the question: What do you think about the surface of the cladding?

## Data

During three days of data gathering 313 persons responded to our questionnaire. 35 of the forms had excessive degrees of missing values and were eliminated from the dataset, so that we were left with 278 forms which amounted to 834 observations (278 forms * 3 surfaces). The remaining data had only a small degree of missing values (maximum 2.4% of observations of any variable). These were replaced by series mean.

Table 3 provides descriptive data and correlations between the measures. As evident, observed variable means are in the neighborhood of 4. Structural equation modeling with maximum likelihood estimator assumes multivariate normality (Bollen, 1989). Prelis 2.0 provides Mardia's (1970; 1974; 1985) test of multivariate normality, and rejects the hypothesis of multivariate normality (p-value<0.000). As evident from table 3, most of the variables, except the measures of perceived harmony, have insignificant univariate skewness, however most of the variables deviate significant from

**Table 3:** Descriptive statistics and correlations

| | | | Skewness | | | Kurtosis | | | Skewness and kurtosis | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Mean** | **Std. Dev.** | Sta-tistic | Z-score | P-value | Statistic | Z-score | P-value | Z-score | P-value |
| Like | 4.0 | 1.8 | -0.1 | -1.4 | 0.17 | -0.9 | -11.5 | 0.00 | 133.6 | 0.00 |
| Want | 3.8 | 1.9 | 0.0 | 0.3 | 0.75 | -1.2 | -22.4 | 0.00 | 501.7 | 0.00 |
| Recommend | 4.0 | 1.8 | -0.1 | -0.8 | 0.41 | -1.0 | -12.5 | 0.00 | 155.8 | 0.00 |
| Quality | 4.2 | 1.6 | -0.2 | -1.8 | 0.07 | -0.6 | -5.5 | 0.00 | 34.0 | 0.00 |
| Expensive | 3.9 | 1.5 | 0.0 | 0.0 | 0.99 | -0.5 | -4.1 | 0.00 | 16.9 | 0.00 |
| Exclusive | 3.6 | 1.5 | 0.1 | 1.0 | 0.30 | -0.4 | -2.6 | 0.01 | 7.9 | 0.02 |
| Fashionable | 3.7 | 1.4 | 0.0 | 0.2 | 0.82 | -0.3 | -2.4 | 0.02 | 6.0 | 0.05 |
| Harmonious | 4.4 | 1.6 | -0.3 | -3.9 | 0.00 | -0.6 | -5.3 | 0.00 | 42.9 | 0.00 |
| Comfortable | 4.5 | 1.7 | -0.4 | -4.1 | 0.00 | -0.8 | -7.4 | 0.00 | 70.9 | 0.00 |
| Restful | 4.4 | 1.7 | -0.2 | -2.6 | 0.01 | -0.8 | -8.0 | 0.00 | 70.9 | 0.00 |
| Balanced | 4.4 | 1.6 | -0.3 | -3.3 | 0.00 | -0.7 | -6.2 | 0.00 | 50.1 | 0.00 |
| Stimulating | 3.9 | 1.5 | -0.1 | -0.8 | 0.42 | -0.6 | -4.9 | 0.00 | 24.8 | 0.00 |
| Interesting | 3.9 | 1.5 | 0.0 | -0.4 | 0.70 | -0.6 | -5.4 | 0.00 | 28.8 | 0.00 |
| Imaginative | 3.8 | 1.4 | -0.1 | -0.6 | 0.53 | -0.3 | -2.1 | 0.04 | 4.6 | 0.10 |
| Experience | 3.8 | 1.5 | -0.1 | -0.8 | 0.43 | -0.4 | -2.7 | 0.01 | 7.7 | 0.02 |

**Correlations***

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Like | **1** | | | | | | | | | | | | | | |
| 2 | Want | **0.89** | **1** | | | | | | | | | | | | | |
| 3 | Recommend | **0.87** | **0.88** | **1** | | | | | | | | | | | | |
| 4 | Quality | **0.58** | **0.56** | **0.57** | **1** | | | | | | | | | | | |
| 5 | Expensive | **0.52** | **0.49** | **0.52** | **0.86** | **1** | | | | | | | | | | |
| 6 | Exclusive | **0.51** | **0.50** | **0.50** | **0.77** | **0.81** | **1** | | | | | | | | | |
| 7 | Fashionable | **0.53** | **0.54** | **0.54** | **0.63** | **0.65** | **0.70** | **1** | | | | | | | | |
| 8 | Harmonious | **0.57** | **0.53** | **0.54** | **0.65** | **0.63** | **0.55** | **0.53** | **1** | | | | | | | |
| 9 | Comfortable | **0.59** | **0.54** | **0.55** | **0.62** | **0.59** | **0.53** | **0.52** | **0.82** | **1** | | | | | | |
| 10 | Restful | **0.51** | **0.48** | **0.49** | **0.62** | **0.58** | **0.50** | **0.49** | **0.78** | **0.83** | **1** | | | | | |
| 11 | Balanced | **0.51** | **0.49** | **0.50** | **0.61** | **0.57** | **0.50** | **0.51** | **0.79** | **0.81** | **0.84** | **1** | | | | |
| 12 | Stimulating | **0.18** | **0.17** | **0.14** | 0.08 | **0.09** | 0.08 | **0.15** | **0.11** | **0.13** | 0.02 | **0.10** | **1** | | | |
| 13 | Interesting | **0.23** | **0.22** | **0.20** | **0.10** | **0.11** | **0.10** | **0.15** | **0.14** | **0.18** | 0.08 | **0.16** | **0.79** | **1** | | |
| 14 | Imaginative | **0.17** | **0.17** | **0.16** | 0.06 | 0.07 | **0.09** | **0.16** | 0.08 | **0.11** | 0.01 | **0.08** | **0.65** | **0.72** | **1** | |
| 15 | Experience | **0.16** | **0.16** | **0.13** | 0.05 | 0.06 | 0.06 | **0.12** | 0.05 | 0.08 | -0.02 | 0.05 | **0.65** | **0.73** | **0.84** | **1** |

*Bold correlations are significant at 1% level

univariate normality in terms of negative kurtosis (using D'Agostinos (1986) test of univariate normality provided by Prelis 2.0). Due to the large sample size (834), rejection of univariate normality with D'Agostinos test is of little value (Kline, 2004). Since few none of the statistics are extreme (>3 for skewness and >10 for kurtosis according to Kline (2004)) we judge the deviation from the multivariate normality as so small that it is unproblematic. As evident from table 3, most correlations are highly significant, especially if the items are hypothesized to measure the same latent variable.

## Analysis

### Analytic strategy

Since this study tests the measures of the latent variables for the first time, we anticipate that the initial measurement model might be rejected. We therefore conduct a two-stage analysis involving a calibration stage and a validation stage. This means that we split the sample in two parts, each containing a random draw of half of the informants (139 informants * 3 surfaces = 417 observations in each set), the first dataset constituting a calibration dataset and the second a validation dataset. In the calibration stage we test the dataset and utilized the modification indices provided by Lisrel 8.72 (a Lagrange Multiplier test) in order to fit a new model to the calibration data. In the validation stage we use the multiple group feature of Lisrel 8.72 in order to test if the calibrated model fit the validation dataset equally well.

### Calibrating the measurement model

Results with standardized parameter estimates from testing the initial measurement model are presented in figure 2. As evident, core fit-values are poor. $\chi^2$ is high rejecting the hypothesis of exact fit. RMSEA is higher than 0.08 (90% confidence interval for RMSEA=[0.077; 0.096]), indicating poor approximate fit. Further, Critical N is only 144, while SRMR is 0.045. The modification indices indicate several problems with the model. First, the

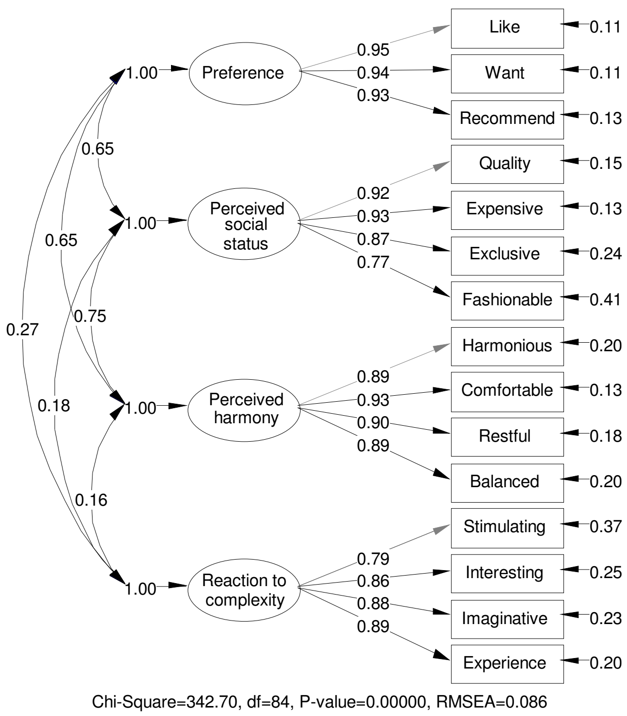


**Figure 2:** Results from testing the initial model on the calibration dataset (standardized parameter estimates)

fourth indicator of perceived social status (out of fashion/ fashionable) work poorly. It has higher error variance (0.41) and lower loading (0.77). This is possibly because this variable to a higher degree measures something else than social status of the product than the other items, possibly also the informants' attitude towards wood more generally. Second, the third indicator of harmony (restless/restful) has high modification indices (in total), even though it has high loading (0.9) and low error variance (0.18). Possible reason for this is that it shares too much variance with reaction to complexity or that it is a too vague question. Both of these items (Status4 and Harmony3) are therefore removed from the model. Third, the modification indices indicate that fit could be improved by allowing for a correlated measurement error between two of the perceived social status items (Status2 and Status3). This is most likely a reflection of the construct being multidimensional, consisting of two closely related dimensions: quality and how rare, expensive or exclusive the product is. As shown by Gerbing & Anderson (1984), use of correlated measurement errors can be mathematically identical to a second-order structure. We therefore open up for a correlated measurement error between those two items. Finally, modification indices suggest improved fit by opening up for a correlated measurement error between the last two indicators of reaction to complexity (Complex1 and Complex2). The reason for this can only be understood from examining the Norwegian version of the items, both of the ending with –rik (-rich) (Fantasiløs/ Fantisirik and Opplevelsesfattig/ Opplevelsesrik). The similarity of these phrases leads most likely these two indicators to constitute a separate dimension of the construct. We therefore open up for a second correlated measurement error between these two items.

We subsequently test the revised model on the calibration dataset. The result is exhibited in figure 3. All paths, error variances and correlations are significant. The $\chi^2$-test rejects the model based on a 5% level as not fitting the data. We nevertheless choose to accept the model based on its approximate fit. There are three main reasons for this. First, overall measures of approximate fit are acceptable (RMSEA=0.035, 90% confidence interval for RMSEA=[0.019; 0.050], SRMR = 0.026, CFI=1.00) (see Hu & Bentler, 1999, for cutoff criteria). Second, further analyses of the model, including examination of modification indices and model re-testing, indicate three main sources of misfit, that are significant, but small. Perceived harmony positively affects Prefer1 (Dislike/Like) (parameter: 0.07). This is likely because people may like the product due to its perceived harmony, but they do not necessarily want to use it in their own home or recommend it to others. Further, reaction to complexity negatively affects Prefer2 (Does not recommend to other/Does very much recommend to others) (parameter:-0.07). The measures of reaction to complexity are arguably more subjective and less connected to physical wood properties (see also Broman, 2001). People may take into account that others may not think like themselves, which subsequently lead to a weaker effect of reaction to complexity on this preference measure than on the others. Finally, perceived harmony affect Complex2 (Uninteresting/Interesting) (parameter: 0.06). This means that perceived harmony has an extra strong effect on the inclination to judge the surface as interesting (Complex2), which may be because knot free pine claddings are unusual. The third reason for accepting the model despite being rejected by the $\chi^2$-test is

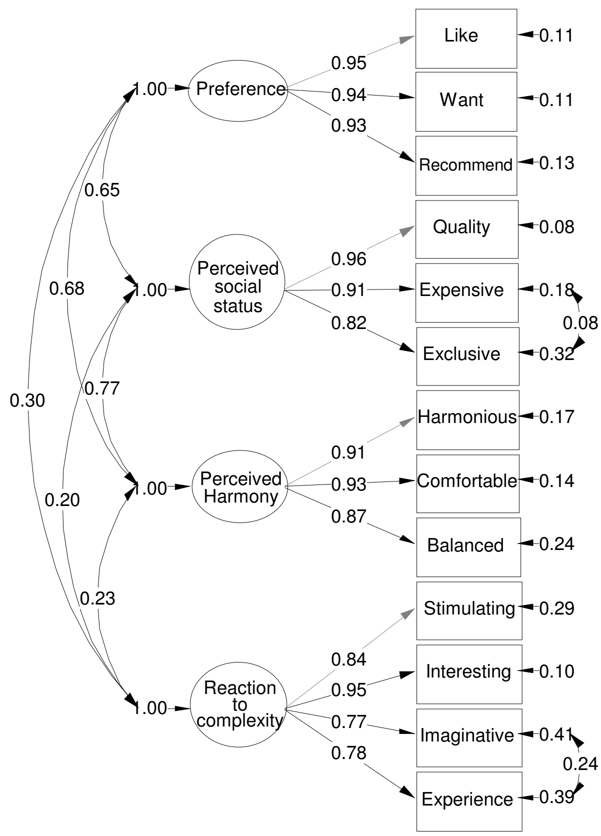


**Figure 3:** Results from testing the revised model on the calibration dataset (standardized parameter estimates).

that it is a relatively parsimonious model that has a good fit considering the number of observations. Critical N is 391. Opening up the paths just described to account for misfit gives a model not rejected by the $\chi^2$-test [$\chi^2$(df)=69.7(54), p-value=0.07]. However, the new effects are small, and the parsimony-normed fit index declines from 0.72 to 0.69. We therefore conclude that this model has satisfactory approximate fit.

**Validating the measurement model**

The next step is to test if the calibrated model holds also in the validation dataset. This is accomplished by first estimating the model in both datasets letting parameter estimates for the two datasets be different. Doing this gives a $\chi^2$ of 192.86 with 114 degrees of freedom. Next, we test the same model on the two datasets, but restrict all parameter estimates to be equal. This gives a somewhat higher $\chi^2$ of 218.78 with 148 degrees of freedom. The $\chi^2$-difference is 25.92 between these models with a difference in degrees of freedom of 34. The p-value of this test is 0.84, indicating that restricting parameter estimates in these two models to be equal does not significantly reduce fit. This indicates that the model generated during the exploratory calibration step performs equally well in an independent sample.

**Assessing unidimensionality, reliability and validity**

To assess unidimensionality, reliability and validity we test the measurement model on all the data merged into one dataset. The results are presented in figure 4. Two of the constructs, perceived social status and reaction to complexity, are not unidimensional, which is explicitly accounted for in the model. Unidimensionality, internal and external consistency is more generally indicated by a measurement model that fits the data, and small modification indices (Bagozzi & Yi, 1988; Ping, 2003). Although the $\chi^2$-test rejects the model, it has overall acceptable approximate fit (RMSEA=0.034, 90% confidence interval for RMSEA=[0.024; 0.043], SRMR=0.020, CFI=1.00, Critical N=626). None of the modification indices are higher than 10.9, meaning that opening up new paths will not explain much more of the variation in the data. This indicates that the model has acceptable unidimensionality, internal and external consistency. Following Bagozzi & Yi (1988) reliability is judged as satisfactory. All item loadings are higher than 0.6, while all measurement error variances are 0.40 or smaller. Composite reliabilities (CR) (calculated according to Raykov, 2001) are all higher than 0.6, and average variance extracted (AVE) (calculated according to Fornell & Larcker, 1981) for each scale is higher than 50%. With adequate fit, reliability, average variance extracted as well as significant parameter estimates, we conclude convergent validity.

Discriminant validity is assessed in three main ways. Using Fornell & Larcker's (1981) procedure we find that the highest shared variance between any pair of latent variables in the model is between perceived social status and perceived harmony ($0.73^2$=0.53), which is lower than average variance extracted for all variables in the model. This means that all latent variables share more variance with its measures than with other latent variables. Following, Anderson & Gerbing's (1988) suggested procedure, we calculated confidence intervals around correlations between the latent variables. None of them included unity, indicating discriminant validity. Following Jöreskog (1971) we also tested models with pairs of latent variables with the correlation between them constrained and not constrained to unity. The $\chi^2$-difference test reveals if constraining the correlation to unity increases $\chi^2$ significantly. The results from these tests are presented in

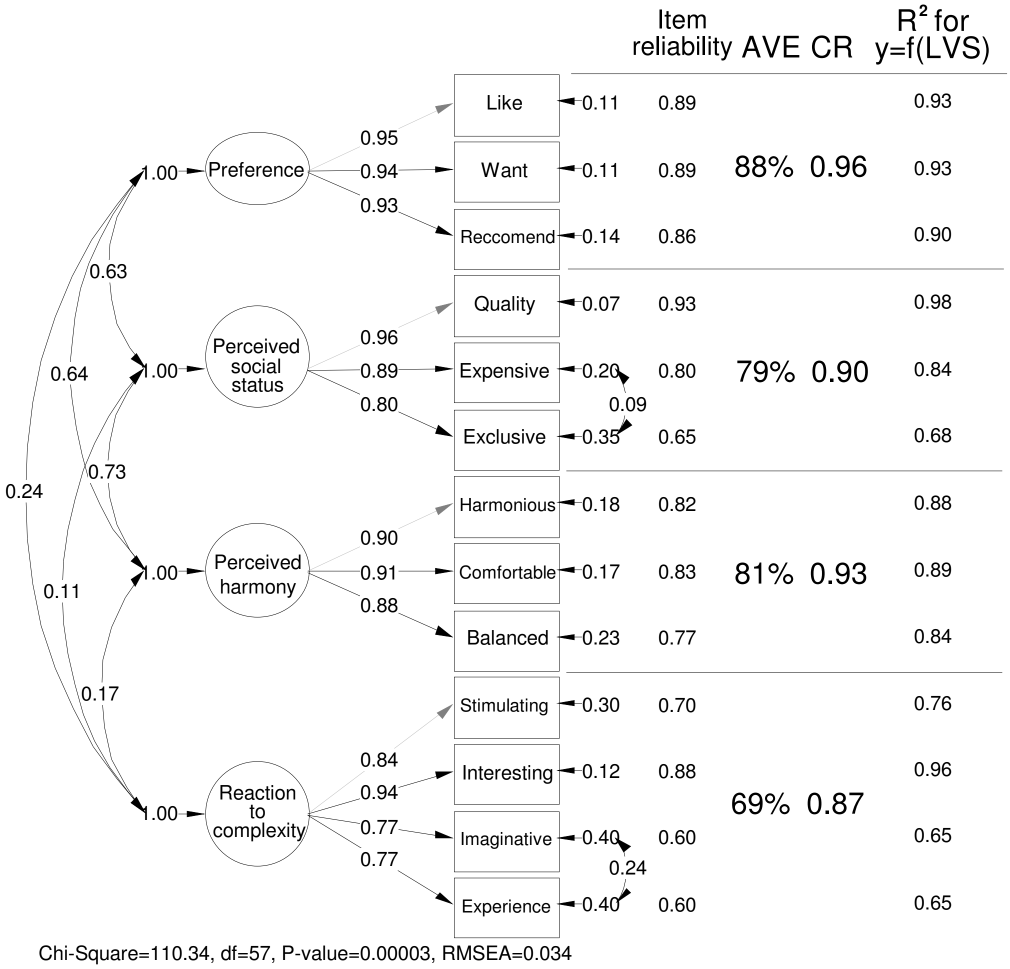


**Figure 4:** Results from testing the revised model on the calibration dataset.

table 4. As evident, the restricted versions of the models had significantly higher $\chi^2$ than the unrestricted ones ($\chi^2$-difference evaluated at 1 degrees of freedom). With satisfying convergent and discriminant validity we can also conclude construct validity.

In sum, in this section we calibrated and re-tested our battery of measures (originally based on Broman 1995a; 1996; 2000a; 2001) for assessing consumer perceptions of wood products. We have used standard psychometric procedures and tests to make conclusions regarding the dimensionality, reliability and validity of the measures. It turns out that the measures work well, having from *a statistical point of view* satisfactory reliability and validity.

## Relationships with physical properties

With measures considered reliable and valid from a statistical point of view we can confidently examine the relationships between the latent variables and their relationships with physical wood properties and as well as variables describing attributes of the consumers and their environment. Moreover, such analyses enables examining the validity of the measures from the perspective that well-grounded hypotheses about the relationships between latent variables should also be supported (Bollen, 1989). If they are not, it should spur further research about why they are not.

The purpose of this study is not conduct such an analysis, and we leave this to future research. However, in order to illustrate the usefulness of such analyses, in figure 5 we exhibit how the different surfaces score on average with respect to the four different latent variables. The surfaces are ordered as in table 1, so that surfaces with a higher number have generally higher numbers of larger and "uglier" (not fresh) knots as well as thicker and more uneven growth rings. The figure indicates mean scores over all informants for each surface with 95% confidence intervals around the means. Scores for latent variables can only be estimated, and there are several ways of doing this.

**Table 4:** Results of two-latent variable models and tests of discriminant validity ($\Delta\chi^2$ evaluated at 1 degree of freedom)

| Latent variable | Latent variable | $\chi^2$ Restricted | $\chi^2$ Unrestricted | $\Delta\chi^2$ |
|---|---|---|---|---|
| Preference | Perceived social status | 576.6 | 25.7 | 550.9 |
| Preference | Perceived harmony | 1361.1 | 24.2 | 1337.0 |
| Preference | Reaction to complexity | 1359.0 | 14.7 | 1344.2 |
| Perceived social status | Perceived harmony | 549.2 | 15.3 | 533.9 |
| Perceived social status | Reaction to complexity | 1377.0 | 11.1 | 1365.9 |
| Perceived harmony | Reaction to complexity | 1653.1 | 21.1 | 1631.9 |

One way is to calculate the mean of the items for each observation; another is to weight the items by their loadings on the latent variable. These methods suffer from not reflecting the nature of the relationship between the variables, and may produce covariance matrixes significantly different from the one between latent variables. A better way may be to use Jöreskog's (2000) Latent Variable Scores (LVS) technique, which is implemented in Lisrel 8.72. The LVS have a covariance matrix identical to the latent variables estimated in the measurement model (illustrated in figure 4). Our experience is that this procedure can be unstable, and no simulation studies have so far been conducted evaluating this procedure (Yang-Wallentin, Schmidt, Davidov, & Bamberg, 2004). Therefore we performed regressions testing the extent to which these scores predict the observed variables. $R^2$ for these regressions are provided in figure 4, and are all satisfactory. We also confirmed that the covariance matrix of the LVS are indeed identical to the one estimated in the measurement model.

From figure 5 we can observe several things. Beginning with perceived harmony, it has a strong relationship with the ordering of the panels. So is the case with perceived social status. This indicates that these variables reflect the informants' evaluation of the surface. Preference shows a similar pattern, although not completely as the responses are more clustered. In particular some of the more knotty surfaces are judged as equally preferred compared to the two clear wood surfaces. Reaction to complexity does not seem to depend on which surface is being evaluated.

## Discussion and conclusions

When examining consumer preferences for wood, it is important to understand the latent variables and observed variables we are dealing with and how they relate to each other. Latent variables need to be clearly defined, and their relationships to the observed variables should be hypothesized and tested. This gives us the possibility to assess the reliability and validity with which the observed variables measure the latent variables. This study has concluded that preference for and perceived social status and perceived harmony of wood surfaces can be measured with satisfying reliability and validity. The study also found that several questions that have been used earlier had to be discarded as measures of the core constructs.

Perceived harmony social status were both suggested by Broman (2001) and the results therefore support two of the latent variables suggested by Broman. The importance of visual homogeneity and harmony has also been supported in other previous research (cf. Nyrud, Roos and Rødbotten, 2008). Furthermore, both variables were closely related to the wood properties of the ten wood surfaces that were used in the study. Surfaces without knots or with small fresh knots did in general get high scores, cf.

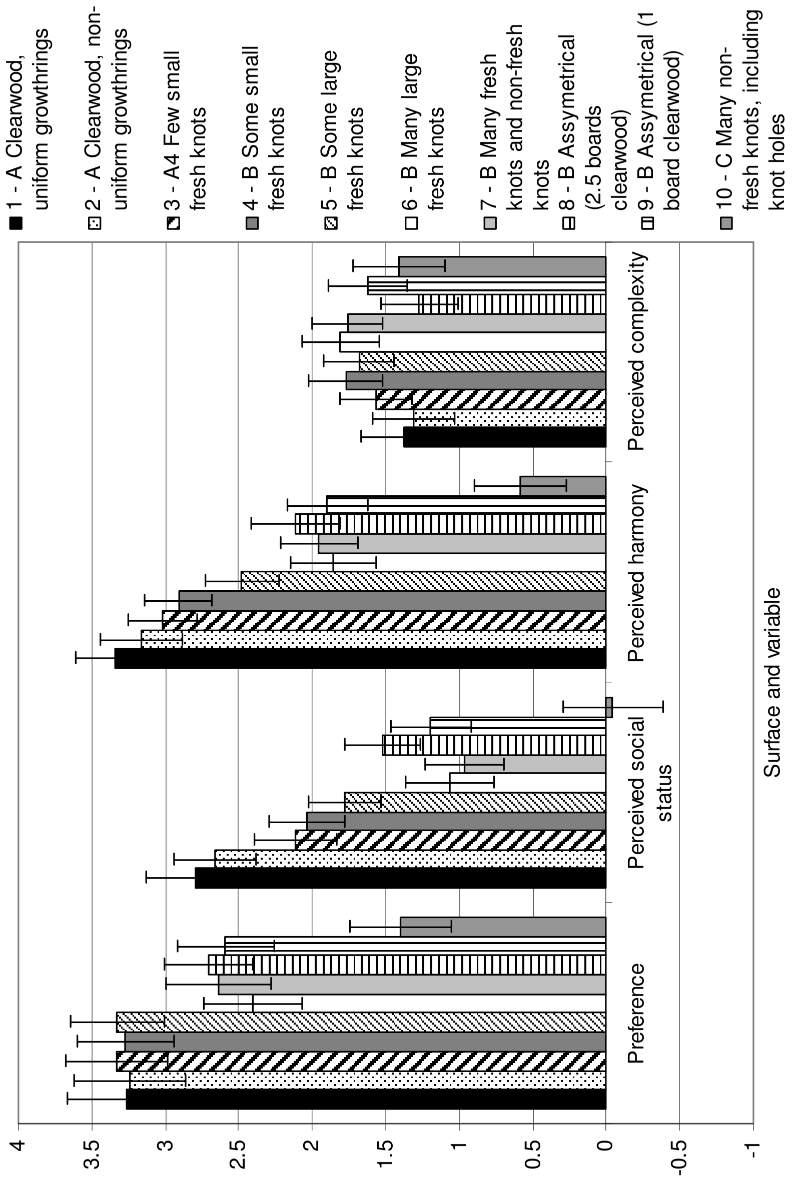


**Figure 5:** Scores for the different surfaces (number 1 to left, 10 to the right).

figure 5. Surfaces with large fresh knots, dry knots or other defects got substantially lower scores and are not preferred by customers.

Reaction to complexity was also confirmed in the model. But this variable does not depend on what surface is being evaluated, indicating that this variable has little to do with the actual surfaces being analyzed. Still, as evident from figure 4, reaction to complexity is positively correlated with preference, and the measures are grounded in people's immediate reactions to wood surfaces (see Broman, 1995b). Broman (2001) found that this variable is particularly important for preference if the surface is perceived as harmonious. But it probably does not reflect Broman's (2001) original label, "activity", i.e. "the overall blend of wood properties". Our initial discussion seems to fit the result, and until its exact nature and relationship to the physical wood properties is understood, we propose that this variable represents reaction to complexity.

A clue to how further research should be conducted may be found in Reber, Schwarz & Winkielman (2004) theory of processing fluency. Reaction to complexity may capture cognitive or emotional reactions to the surface produced by an interaction between the physical properties of the surface, perhaps in particular its complexity, and various attributes of the informants. These informant attributes may be factors such as their prior experience, attitudes, preferences, and expectations, as well as situational factors. We leave it to future research to explore these issues further, developing better construct definitions and measures of the various reactions people have to a surface.

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# An econometric analysis of the timber supply in ten north-western European countries

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## Abstract
The paper presents an econometric analysis of the timber supply in ten Northwestern European countries. For each country, the time series covers the years 1980 - 2006. Several factors, in addition to the log price and the growing stock, are analysed, to study the elasticity of supply. Three different models were tried, with common and individual slope and intercept coefficients. Pooled OLS estimation of the fully homogeneous model gave significance of all coefficients. We met difficulties of finding consistent estimators of all coefficients while estimating the model with homogenous slope coefficients and heterogeneous intercept. The OLS and GLS estimators are not consistent due to correlation between the explanatory variables and the latent country-specific effect. Probably because of low variation within countries, within-estimators (fixed effects) / Hausman-Taylor estimators are not appropriate instruments, they gave negative estimates of the price coefficient. OLS of the fully heterogeneous model resulted in wrong sign of many estimates. The elasticity of supply with respect to price and growing stock for all countries as a whole was in the pooled OLS found to be 0.14 and 0.88, respectively.

**Keywords:** Econometric analysis, timer supply, panel data

## Introduction
Several studies of timber supply with use of panel data are done (Baardsen 1998; Bolkesjø, Buongiorno *et al.* 2008*)*. But few studies on aggregated national level are carried out. Turner, Buongiorno *et al.* (2006) is one exception. The objective of this study is to analyse the elasticity of supply, first and foremost with the regard to price and growing stock, but also with regard to other relevant factors. All countries investigated are in northwestern Europe. Nevertheless, there are huge differences regarding forest resources and the importance of forest industry. Any difference between the countries regarding the abovementioned elasticities are of high interest to analyse.

## Methods and material

**Economic model**

Long-run supply and demand models build upon the assumption that capital markets are perfect, i.e. the borrowing rates and interest on loans are equal. In addition, no uncertainty is assumed. The decision criterion for a single supplier is maximizing net present value, where the variables are harvest and inputs, and the condition growing stock. The supply is supposed to satisfy the Cobb-Douglas production function, also on aggregated level.

The following variables are included in the model (assumed correlation between the explanatory variables and the dependent variable is in parenthesis):

Dependent variable: Harvested volume of industrial coniferous roundwood

Explanatory variables:

- Log price (+)
- Real rate of interest (+)
- Growing stock (+)
- Gross domestic product (GDP) per capita (-)
- Contribution of the forest sector to the country's GDP (+)
- Population density (-)

Harvest is assumed positively correlated with log price, growing stock and real rate of interest, according to theory of economics and forest economics. GDP per capita is a proxy for the welfare, and it is assumed negatively correlated with harvest. Two reasons (at least) may explain this trend: With increasing welfare, a society becomes more concerned about the forest's non-timber values, as biodiversity. A richer country is thus supposed to put more regulations on the forestry and to protect more forest. In addition, higher GDP signifies higher general income, resulting in higher alternative value of forest owners' time. Thus, forest owners may work more outside forestry, and will then spend less time in managing and harvesting the forest. Contribution from forestry and forest industries to the GDP is assumed to be positively correlated with harvest. The higher importance this sector has in the economy, the better harvesting systems and policy and fiscal incentives for harvesting may be. Population density is supposed to be negatively correlated with the harvest, because a denser populated country probably is more aware of the qualities of forest for recreation, posing more restrictions on forestry and harvest.

**Data**

The panel consists of observations from 1980 to 2006 of the following ten European countries: Norway, Sweden, Finland, Denmark, Germany, Austria, Switzerland, France, Netherlands and UK.

The data set contains two time-invariant (country-specific) explanatory variables, the forest sector's contribution to the country's GDP and the population density. The other five variables vary over year and country.

Data of harvest and log price were collected from Faostat. However, this database does not provide domestic prices of wood and wood products, only quantities and total values of export and import, as well as domestic production and harvest. To obtain prices in the respective countries, a weighted price was found by using the formula:

$$\text{Weighted price} = \frac{\text{total export value + total import value}}{\text{export quantity + import quantity}}$$

Until 1989, the roundwood is divided into two main groups, saw logs + veneer logs and coniferous pulpwood. From 1990, there is only one group of timber, industrial coniferous roundwood. For 1980-1989, the log price is the weighted price of the (weighted) saw logs and pulpwood price. All values were given in US dollars, but are deflated to constant (2006) prices. Data of harvest are divided into two groups, saw logs + veneer logs and pulpwood, in all years. Figures 1 and 2 display the time series of roundwood price and annual removals.

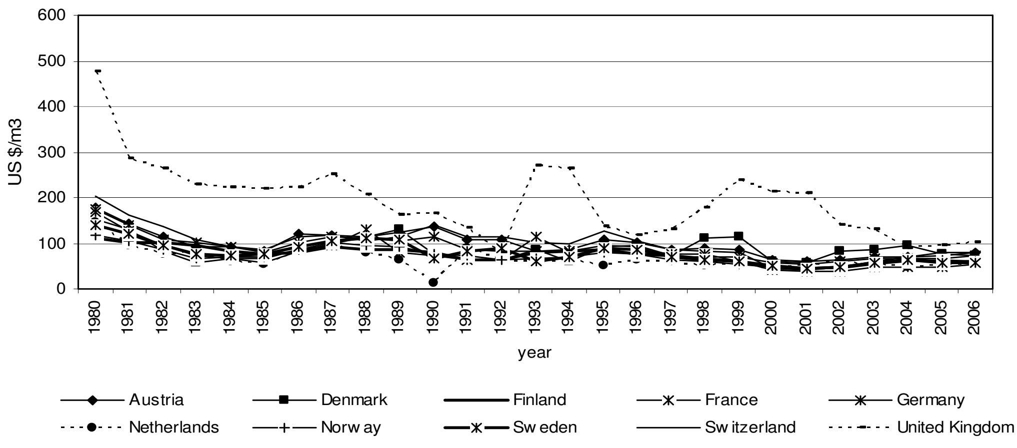


**Figure 1: Weighted industrial roundwood price (US \$/m$^3$, constant 2006 prices).**

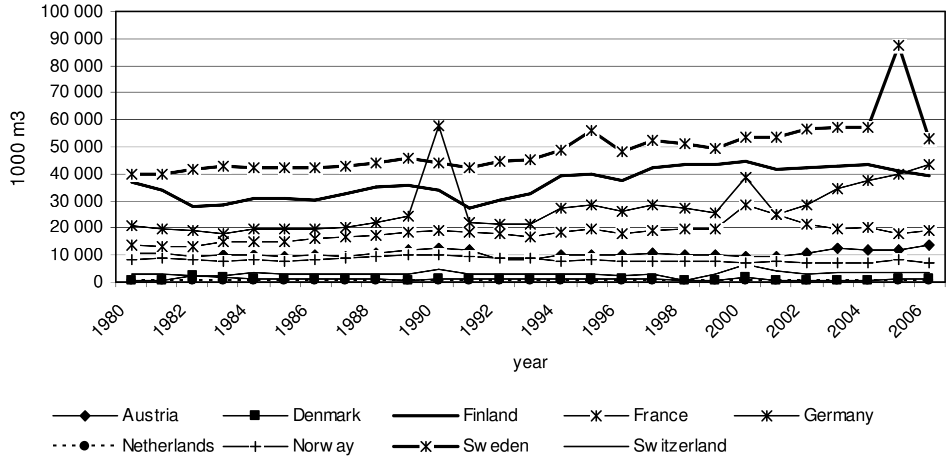


**Figure 2: Removals of coniferous industrial roundwood (1000 m$^3$).**

Data of growing stock for the 1980 and 1990 are from the Kussela database. For the years after 2000 and 2005, the data are from the MCPFE report 2007. To obtain a yearly growing stock, the data were interpolated and extrapolated (Figure 3). The MCPFE report does not contain data for Germany in 2005, so this observation was found in Federal Ministry of Food, Agriculture and Consumer Protection (2007).

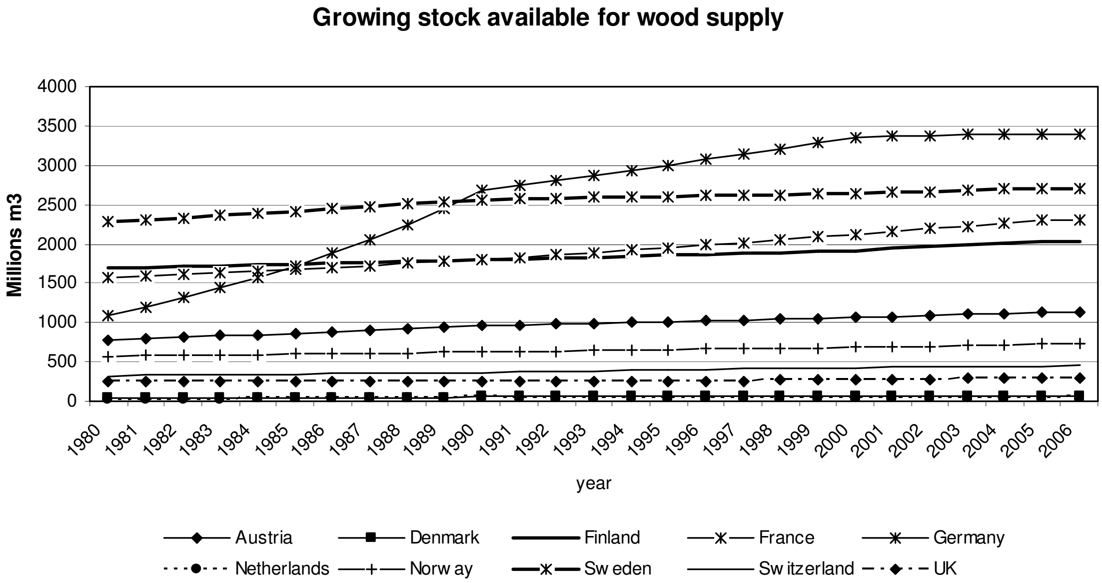


**Figure 3: Growing stock (M m$^3$)**

Storms have caused exceptionally high removals in some countries and years, and may also cause price disturbances, leading to troubles in estimation. The storm years were removed from the harvest and price data set. For the years 1980-1999, the storm years were identified from the DFDE database, developed by the European Forest Institute and the Alterra in the Netherlands. Observations of price and harvest in years with storm felling larger than 30 % of the year's removal were removed from the dataset. We do not have data of storm felling after 1999. For these years, observations of price and harvest in years with larger removals than 30 % more than the last five years' average were deleted. The observations of harvest and price dropped due to high storm felling are displayed in Table 1.

**Table 1: Observations deleted from the data set of removals and prices due to large storm fellings.**

| Country | Years dropped |
|---|---|
| Austria | 1990,1995 |
| Denmark | 1981, 1983, 1984, 1990, 1999, 2000, 2005,2006 |
| Finland | None |
| France | 1982, 1987,1990, 1999, 2000 |
| Germany | 1984, 1990, 1999, 2000 |
| Netherlands | 1990 |
| Norway | None |
| Sweden | 2005 |
| Switzerland | 1990, 1999, 2000 |
| UK | 1987, 1990 |

Data of gross domestic product (GDP) and inflation are from World Economic Outlook's online database (http://www.imf.org/external/-ns/cs.aspx?id=28). Nominal interest rates are from International Financial Statistics' online database (http://www.imfstatistics.org/imf). GDP and all prices are in 2006 US dollar prices. The consumer price index for the United States is applied for deflating GDP and prices (ftp://ftp.bls.gov/pub/special.requests/cpi/cpiai.txt) to 2006 prices. Due to some negative observations, the constants 5 and 1 were added to all data of interest rates and the forest sector's contribution to the national GDP, respectively, to avoid problems when use of the logarithm.

Data of the countries' population density (population and area) are from CIA World Factbook 2007, contribution of the forest sector to the national GDP from FAO (Lebedys 2004) (Table 2).

**Table 2: The forest sector's contribution to the GDP in percent (average 1990-2000) and the population density in million inhabitants per square km (2007).**

| Country | Contribution to the GDP | Population density |
|---|---|---|
| Austria | 2 | 98 |
| Denmark | 1 | 127 |
| Finland | 7,6 | 15 |
| France | 1 | 111 |
| Germany | 1,1 | 231 |
| Netherlands | 0,7 | 399 |
| Norway | 1,5 | 14 |
| Sweden | 3,7 | 20 |
| Switzerland | 2 | 183 |

Table 3 shows the summary statistics for the variables, after removals of price and harvest in storm years, but before adding of constants to the interest rate and the forest sector's contribution to the GDP.

**Table 3: Statistics for the variables used**

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| harvest | 244 | 16232.4 | 16088.97 | 413.0002 | 57400.02 |
| log_price | 244 | 93.73687 | 50.34506 | 37.18642 | 477.0479 |
| gr_stock | 270 | 1127.18 | 997.3294 | 23.3625 | 3401.003 |
| real_int_r~m | 270 | 3.182376 | 2.509208 | -4.538979 | 15.7608 |
| gdp_cap | 270 | 33582.46 | 9498.331 | 14961 | 72430 |
| for_contr_~p | 270 | 2.16 | 1.997292 | .7 | 7.6 |
| pop_density | 270 | 144.6 | 117.4091 | 14 | 399 |

## Econometric supply models

Three econometric models are considered:

<u>Model 1: Lin-log model with common intercept and slopes</u>

$\ln(y_{it}) = \alpha + \beta_1 \ln(x_{it,1}) + \beta_2 \ln(x_{it,2}) + \beta_3 \ln(x_{it,3}) + \beta_4 \ln(z_{it,1}) + \beta_5 \ln(z_{it,2}) + u_{it}$

<u>Model 2: Lin-log model with common slopes and individual intercept</u>

$\ln(y_{it}) = k + \alpha_i + \beta_1 \ln(x_{it,1}) + \beta_2 \ln(x_{it,2}) + \beta_3 \ln(x_{it,3}) + \beta_4 \ln(z_{it,1}) + \beta_5 \ln(z_{it,2}) + u_{it}$

<u>Model 3: Lin-log model with individual slopes and intercept</u>

$\ln(y_{it}) = k + \alpha_i + \beta_{i,1} \ln(x_{it,1}) + \beta_{i,2} \ln(x_{it,2}) + \beta_{i,3} \ln(x_{it,3}) + \beta_{i,4} \ln(z_{it,1}) + \beta_{i,5} \ln(z_{it,2}) + u_{it}$

The first model is fully homogenous. Model 2 is homogenous in the slope coefficients, while the third model is heterogeneous in the slope coefficients, as well as in the intercept.

**Tests and estimation**

Simultaneity

The simultaneity problem may occur when estimating supply on a macro level, if the price shows to be endogenous. The quantity supplied may be affected by other variables only included in the error term, and the change in quantity may in next turn influence the price. Price is thus correlated with the error term, violating one of the assumptions of the classical linear regression model. As a result, the ordinary least squares (OLS) estimators are not consistent. Two-stage least squares (2SLS) and three-stage least squares (3SLS) may be applied in the case of simultaneous equations. But in case of no simultaneity the OLS estimators are both consistent and efficient. With use of the Hausman Specification test, it can be tested whether some of the regressors are endogenous (Gujarati 2003).

The first step in the Hausman Specification test is to regress the assumed endogenous variable on the other regressors in the equation, and then, obtain the estimates of the error terms. Then, regression of the original regressand on all regressors, together with the estimates of the residuals, $\hat{u}$, with a following t-test, may display simultaneity of $\hat{u}$ and the regressor.

We performed Hausman test on all models 1, 2 and 3 (for each country), by first regressing the price on the other explanatory variables in the model. Thereafter, we generated the variable $\ln(\hat{u}_{it} + 1)$, adding 1 to avoid negative numbers. The harvest variable was regressed on all variables, including the generated error term. For all model, we concluded that there is no simultaneity. All countries may thus be seen as price-takers.

Autocorrelation

On the basis on Durbin-Watson tests for first-order autocorrelation in the individual lin-log, most countries in the sample showed possibly positively autocorrelation, but were in the zone of indecision, so we could not conclude whether there is first-order autocorrelation or not. For Austria and Norway, we could not reject the zero-hypothesis of no autocorrelation, for Denmark, France and UK, the Durbin-Watson statistics were respectively 0.212, 0.741 and 0.494, and in these cases, the zero-hypothesis was rejected (Gujarati 2003). In case of autocorrelation, OLS is still consistent and unbiased, but not efficient, causing problems of inference procedure of tests. FGLS (Feasible GLS) is both consistent and efficient in large samples with autocorrelation. But, there is a problem using FGLS in small samples, because the properties of the estimators in small samples are not well documented. According to Gujarati, Griliches and Rao executed a

Monte Carlo study and found that in cases of small samples and low coefficient of autocorrelation (usually less than 0.3), the OLS estimators are as good as or better than the FGLS estimators. For these three countries with autocorrelation, the coefficient of autocorrelation was found to be 0.26, 0.12 and 0.001, respectively. Thus, OLS is used for all countries in the country-specific models (model 3).

Consistency and efficiency

OLS provides MVLUE (minimum variance, linear unbiased estimators) of the coefficients in model 1, with only homogenous parameters (Biørn 2007).

Consider model 2:

$y_{it} = k + \mathbf{x}_{it}\boldsymbol{\beta} + \mathbf{z}_i\boldsymbol{\delta} + \alpha_i + e_{it}$, $e_{it} \sim IID(0, \sigma^2)$, $i = 1, ... N$, $t = 1, ... , T$

We can "choose" whether we will consider this model as fixed or random. If the model is considered as a random effect (RE) model, the $\alpha_i$'s are supposed to be stochastic, with a distribution around 0, and a variance $\sigma_\alpha^2$. These variables contain country-specific factors which are not specified in the model. Property structure and how well-working the markets and the forest owner organizations may be such factors in this study. In a fixed effect (FE) model, the $\alpha_i$'s are seen as unknown constants. Whether the model is regarded as fixed or random influence the consistency, as well as the efficiency, of the estimators. An interesting question in that context is presence of unobserved heterogeneity between the countries, and if this heterogeneity is so large that it should be taken into consideration in the model specification. If there is such heterogeneity, the next question is the correlation between this heterogeneity and the explanatory variables. Let us look at this first point first.

There are several indicators of the occurrence of such heterogeneity. From the FE estimation, we can perform F-tests of heterogeneity:

$H_1$: No individual heterogeneity: $\alpha_1 = \ldots = \alpha_N = \alpha$, $\beta_1 = \ldots = \beta_N = \beta$ (model 1)

$H_2$: Individual intercept heterogeneity, common slope: $\alpha_1, \ldots, \alpha_N$ unrestricted, $\beta_1 = \ldots = \beta_N = \beta$ (model 2)

$H_3$: Full individual heterogeneity: $\alpha_1, \ldots, \alpha_N$ and $\beta_1, \ldots , \beta_N$ are unrestricted (model 3)

To test to what degree there is heterogeneity, three tests are performed: $H_2$ against $H_3$, $H_1$ against $H_2$ and $H_1$ against $H_3$ (Biørn 2007).

From the output of the statistical software, we can obtain the results of a F-test of the hypothesis that $\sigma_\alpha^2 = 0$ from the FE estimation. The total unexplained variance in the model is given by $\sigma_\alpha^2 + \sigma^2$. The RE report indicates how much of the total unexplained variance which is due to the individual heterogeneity, $\sigma_\alpha^2 /( \sigma_\alpha^2 + \sigma^2 )$.

Breusch-Pagan test is performed of the RE model: $H_0$: $\sigma_\alpha^2 = 0$ vs. $H_1$: $\sigma_\alpha^2 > 0$. If we have stated that there is such individual heterogeneity, the next question is whether the latent (unobserved) heterogeneity ($\alpha_i$) is correlated with some of the explanatory variables ($\mathbf{x}_{it}$ or $\mathbf{z}_i$). This question is important in deciding if the RE or the FE model is to be used. The RE model with GLS estimation is the most efficient method, but for being consistent, it requires that all explanatory variables ($\mathbf{x}_{it}$ and $\mathbf{z}_i$) are uncorrelated with $\alpha_i$ (Hausman and Taylor 1981). OLS provided inconsistent estimators of the same reason; in addition, the OLS estimators are less efficient than the GLS estimators. If there is correlation, a kind of misspecification problem arises (omitted variables bias), resulting in inconsistence. The estimates of the coefficients will be affected by the $\alpha_{i,}$ and hence, we are not able to estimate the partial effect of $x_{it1}$ or $z_{i1}$ on $y_{it}$. What about the FE model? The estimation method for FE models is within-estimation, where only the variation within the countries is exploited for estimate the slope coefficients. Using within-estimation solves one problem and give arise to several others: Even if there is correlation between the unobserved heterogeneity and some of the explanatory variables, the within-estimation provides consistent and estimators of the slope coefficients. So far, so good. But, as a consequence of only applying the variation within the countries, it is not possible to separate $\delta$ and $\alpha_i$, i.e. we are not able to distinguish the country-specific effect $\alpha_i$ and the effects of the individual explanatory variables $\mathbf{z}_i$. We only get one estimator of these coefficients together, which is hard to interpret. Often, we are interested in the effects of the individual variables, which we are not able to find using the within-estimation. In addition, the estimates obtained (i.e. the estimates of $\boldsymbol{\beta}$) are not efficient, since only the within-variation is used for estimation, and nothing of the between-variation. The estimators' variance is consequently larger than in the RE model. Thus, there is a trade-off between efficiency and robustness. The third problem while using within-estimation is the consistency of the $\alpha_i$'s, which are consistent only if T (the number of periods) goes to infinity. If N (the number of countries) goes to infinity and T is finite, then the number of variables increases to infinity, while the number of observations rests limited, resulting in inconsistent $\alpha_i$'s.

The printout of the FE model gives an estimate of the correlation between the fixed effect and the regressors.

We can also make a formal test for the correlation between the regressors and the country-specific effects (Hausman Specification test):

The average of the observations over the periods within a country is given by $\underline{\mathbf{x}}_{i*} = (1/T)*\Sigma^T x_{it}$.

The correlation between $\alpha_i$ and $(\underline{\mathbf{x}}_{1*}, \mathbf{z}_i)$ is formalized as
$\alpha_i = c + \underline{\mathbf{x}}_{i*}\boldsymbol{\lambda} + \mathbf{z}_i\eta + u_i$
$H_0$: $\boldsymbol{\lambda} = \boldsymbol{\eta} = \mathbf{0}$. Both within and GLS estimators are consistent, GLS is efficient.
$H_A$: $\boldsymbol{\lambda} \neq \mathbf{0}$ and $\boldsymbol{\eta} \neq \mathbf{0}$. GLS estimators are not consistent

If we reject $H_0$ and still want to estimate the country-specific coefficients, there is possibility using the Hausman-Taylor method, where we construct instrument variables within the data set:
Consider the same model:
$y_{it} = k + \mathbf{x}_{it}\boldsymbol{\beta} + \mathbf{z}_i\boldsymbol{\delta} + \alpha_i + e_{it}$, $e_{it} \sim$ IID$(0, \sigma^2)$, $\alpha_i \sim$ IID$(0, \sigma_\alpha^2)$, $u_{it} \perp \alpha_i \perp (\mathbf{x}_{it}, \mathbf{z}_i)$ for all i, t

But now, the explanatory variables are divided into two groups, where the variables denoted 1 are assumed exogenous and the variables denoted 2 are assumed correlated with the latent individual effect. Consequently, $\boldsymbol{\beta} = (\boldsymbol{\beta}'_1, \boldsymbol{\beta}'_2)'$, $\boldsymbol{\delta} = (\boldsymbol{\delta}'_1, \boldsymbol{\delta}'_2)'$. The number of two-dimensional variables is respectiveley $K_1$ og $K_2$, og the number of one- dimensional $L_1$ og $L_2$. The models now looks like:
$y_{it} = k + \mathbf{x}_{1it}\boldsymbol{\beta}_1 + \mathbf{x}_{2it}\boldsymbol{\beta}_2 + \mathbf{z}_{1i}\boldsymbol{\delta}_1 + \mathbf{z}_{2i}\boldsymbol{\delta}_2 + \alpha_i + e_{it}$, $e_{it} \sim$ IID$(0, \sigma^2)$, $\alpha_i \sim$ IID$(0, \sigma_\alpha^2)$,
$u_{it} \perp \alpha_i \perp (\mathbf{x}_{it}, \mathbf{z}_i)$ for all i, t

1. The first step is to take the within-transformation of the model:
$(y_{it} - \underline{y}_{i*}) = (\mathbf{x}_{1it} - \underline{\mathbf{x}}_{1i*})\boldsymbol{\beta}_1 + (\mathbf{x}_{2it} - \underline{\mathbf{x}}_{1i*})\boldsymbol{\beta}_2 + (e_{it} - \underline{e}_{i*})$
From the FE-model, we obtain the consistent estimators of $\boldsymbol{\beta}'_1$ and $\boldsymbol{\beta}'_2$. In addition, we find the residuals from the estimation $\hat{c}_i = \underline{\mathbf{y}}_{i*} - \underline{\mathbf{x}}_{1i*}\boldsymbol{\beta}_1 - \underline{\mathbf{x}}_{1i*}\boldsymbol{\beta}_2$. The estimator for the residual variance is a consistent estimator of $\sigma^2$.
2. Thereafter, we regress $\hat{c}_i$ on $\mathbf{z}_1$ og $\mathbf{z}_2$, where vi use $\mathbf{z}_1$ and $\mathbf{x}_{1it}$ as instrument variables (IV). To have enough IV, $K_1$ has to be at least as great $L_2$. We obtain from here a consistent estimator of $\boldsymbol{\delta}$.
3. The residual variance in the second step is a consistent estimator of $\sigma^{2*} = \sigma_\alpha^2 + \sigma^2/T$
In the first step, we found $\sigma^2$, we can now find $\sigma_\alpha^2$. We weigth the variance for use in FGLS: $o = (\sigma^2 / (\sigma^2 + T * \sigma_\alpha^2))^{1/2}$
4. No, we weigth the IV estimators with the residual variances:
$\mathbf{x}^{*\prime}_{1it} = \mathbf{x}'_{1it} - (1-\hat{o})\, \underline{\mathbf{x}}'_{1i*}$, $y^{*\prime}_{it} = y'_{it} - (1- \underline{y}'_{i*})$
For the four variables $\mathbf{x}_{1it}$, $\mathbf{x}_{2it}$, $\mathbf{z}_{1i}$ and $\mathbf{z}_{2i}$, we use the following variables as IV:
$\mathbf{v}'_{it} = [(\mathbf{x}_{1it} - \underline{\mathbf{x}}_{1i*})', (\mathbf{x}_{2it} - \underline{\mathbf{x}}'_{2i*})', \mathbf{z}'_{1i}, \underline{\mathbf{x}}'_{1i*}]$
Since they are weighted with the residuals, they are more efficient. Even if $\mathbf{x}_{2it}$ is correlated with $\alpha_i$, $(\mathbf{x}_{2it} - \underline{\mathbf{x}}_{2i*})$ is uncorrelated with the $\alpha_i$ beacuse of

ortogonality between the within and the between variation (Hausman and Taylor 1981; Greene 2003, Biørn 2007).

FE estimators only exploit the variation within the country, and are calculated on the basis of the distance from the observation of each year to the average of the observations over all years, for each country: $\Sigma^{N}{}_{i=1} \Sigma^{T}{}_{t=1}(x_{it} - \underline{x}_{i*})$, $\underline{x}_{i*} = (1/T)\ \Sigma^{T}{}_{t=1} x_{it}$ (i = 1, … N, t =1, … T). But it is also possible to calculate the estimators the other direction. Instead of calculating the observations' distance from the average over all periods for each country, we calculate the distance from the average over all countries, for each period:
$\Sigma^{N}{}_{i=1} \Sigma^{T}{}_{t=1}(x_{it} - \underline{x}_{*t})$, $\underline{x}_{*t} = (1/N)*\Sigma^{N}{}_{i=1} x_{it}$. Thus, it is the variation within the time periods which is exploited in the estimation.

The OLS estimators of the parameters of model 3 (full heterogeneity) are MVLUE, despite some autocorrelation.

## Results and discussion

Heterogeneity

All the three performed F-tests of heterogeneity gave evidence of rejecting $H_0$ at a p-level of 0.01, as displayed in Table 4.

**Table 4: Values and statistics for the F-tests of heterogeneity. The number in parenthesis is the approximately critical F values at a p-level of 0.01.**

| | $H_2$ against $H_3$ | $H_1$ against $H_2$ | $H_1$ against $H_3$ |
|---|---|---|---|
| F-value | 6.2751 | 38.3905 | 2.6313 |
| F-statistics | 54.194 under $H_2$ (1.87) | 9.230 under $H_1$ (4.36) | 63.194 under $H_1$ (1.68) |

Thus, there is evidence that there is heterogeneity between the countries, not only in the intercept ($H_2$), but also in the slopes ($H_3$).

On the basis of the F-test that the variance of the individual specific effect is zero ($H_0$), $H_0$ is rejected (F-value: 38.39). The fraction of the variance in the RE model due to $\alpha_i$, i.e. the unexplained individual variance, is 0.60. From the result of the Breusch-Pagran multiplier test of zero variance of the individual effect ($H_0$), we reject $H_0$ ($chi^2(1) = 449.95$).

All these tests give the same result: There is large heterogeneity between the countries which is not taken into consideration in the model. The next question is if this individual effect is correlated with some the explanatory variables.

From the FE model output, the correlation between the regressors and the fixed individual effect is reported to 0.85. Thus, the condition of consistency is violated.

Execution of the Hausman specification test gives the value $chi^2(4) = 33.67$. We can thus reject $H_0$ that both FE and RE models are consistent, and RE is efficient. The problem now is that the RE estimators are not consistent, and within the frames of the FE model, we can not estimate the coefficients of the country-specific variables. A possible solution is Hausman-Taylor estimation.

Table 5 displays the result of the pooled OLS estimation of model 1 (no heterogeneity). The overall $R^2$ value is 0.96.

**Table 5: Result of pooled OLS of model 1. Standard errors are in parenthesis. Significance levels: * = 10 %, ** = 5 %, *** = 1 %.**

| | OLS |
|---|---|
| | b/se |
| ln_log_price | 0.14*** |
| | (0.05) |
| ln_real_rate | 0.19*** |
| | (0.05) |
| ln_gr_stock | 0.88*** |
| | (0.02) |
| ln_gdp_cap | -0.32*** |
| | (0.07) |
| ln_pop_dens | -0.11*** |
| | (0.03) |
| ln_for_gdp | 0.28*** |
| | (0.06) |
| _cons | 5.85*** |
| | (0.92) |

In model 2 (Table 6), heterogeneity is allowed in the intercept, but not in the slopes. All country dummies are significant, except Finland, Netherlands and Norway, which are dropped due to collinarity. Overall $R^2$ of inverse FE is 0.98. The estimates of the two-dimensional coefficients in Hausman-Taylor are identical to those of FE, since the two methods exploit the same variance for estimation of these variables. As seen from the table, none of the estimates of the prices give logical signs of the coefficients.

Three different Hausman-Taylor models were tried, one with the forestry's contribution to the country's GDP as the endogenous variable, another with the growing stock as endogenous. The third model was with both these variables as endogenous. All these models gave negative price coefficient. Because of a lack of exogenous variables, we could not try models with the country dummies as endogenous variables.

**Table 6: Result from RE, Hausman-Taylor (HT) and inverse FE (FE2) of model 2. Standard errors are in parenthesis. Significance levels: * = 10 %, ** = 5 %, *** = 1 %.**

| | RE | HT | FE2 |
|---|---|---|---|
| | b/se | b/se | b/se |
| ln_log_price | -0.20*** | -0.20*** | -0.33*** |
| | (0.05) | (0.05) | (0.07) |
| ln_real_rate | 0.06* | 0.06* | 0.10** |
| | (0.03) | (0.03) | (0.05) |
| ln_gr_stock | 0.18 | 0.20* | 0.24** |
| | (0.11) | (0.11) | (0.12) |
| ln_gdp_cap | 0.15** | 0.14** | -0.22 |
| | (0.07) | (0.06) | (0.15) |
| ln_pop_dens | -0.52*** | 0.45 | -0.53*** |
| | (0.08) | (1.38) | (0.09) |
| ln_for_gdp | 1.13*** | 3.51 | 0.99*** |
| | (0.12) | (4.29) | (0.13) |
| Austria | 1.09*** | | 1.01*** |
| | (0.19) | | (0.20) |
| Denmark | -0.32*** | | -0.20* |
| | (0.10) | | (0.11) |
| France | 1.96*** | | 1.76*** |
| | (0.31) | | (0.34) |
| Germany | 2.66*** | | 2.45*** |
| | (0.39) | | (0.43) |
| Sweden | 1.02*** | | 0.98*** |
| | (0.12) | | (0.13) |
| Switzerland | 0.33** | | 0.50*** |
| | (0.13) | | (0.15) |
| UK | 1.69*** | | 1.67*** |
| | (0.19) | | (0.19) |
| Finland | | | 0.00 |
| | | | (0.00) |
| Netherlands | | | 0.00 |
| | | | (0.00) |
| Norway | | | 0.00 |
| | | | (0.00) |
| _cons | 7.37*** | 1.42 | 11.43*** |
| | (0.88) | (10.28) | (1.76) |

Results of the country-specific estimations (pure time-series) are displayed in table 7. Several countries (Denmark, Finland, France, Germany, Netherlands and Switzerland) have negative price coefficient, none of them are significant.

**Table 7: Result from OLS of model 1. Standard errors are in parenthesis. Significance levels: * = 10 %, ** = 5 %, *** = 1 %.**

| | Austria | Denmark | Finland | France | Germany |
|---|---|---|---|---|---|
| | b/se/R2 | b/se/R2 | b/se/R2 | b/se/R2 | b/se/R2 |
| ln_log_price | 0.73*** | -0.26 | -0.02 | -0.10 | -0.10 |
| | (0.21) | (0.30) | (0.14) | (0.10) | (0.35) |
| ln_real_rate | -0.29** | 0.32 | -0.21*** | 0.14** | -0.72*** |
| | (0.11) | (0.26) | (0.06) | (0.06) | (0.24) |
| ln_gr_stock | 2.29*** | -3.16 | 1.39* | 0.80* | 0.18 |
| | (0.77) | (1.88) | (0.72) | (0.41) | (0.37) |
| ln_gdp_cap | -0.46* | 0.04 | 0.05 | 0.07 | 0.21 |
| | (0.22) | (0.54) | (0.11) | (0.16) | (0.31) |
| ln_pop_dens | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |
| ln_for_gdp | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |
| _cons | -4.46 | 19.33*** | 0.07 | 3.12 | 8.51*** |
| | (4.13) | (5.44) | (5.36) | (2.31) | (2.07) |

| | Netherlands | Norway | Sweden | Switzerland | UK |
|---|---|---|---|---|---|
| | b/se/R2 | b/se/R2 | b/se/R2 | b/se/R2 | b/se/R2 |
| ln_log_price | -0.16 | 0.20 | 0.19* | -0.16 | 0.07 |
| | (0.17) | (0.14) | (0.10) | (0.17) | (0.12) |
| ln_real_rate | 0.32** | 0.23*** | -0.06*** | 0.01 | 0.69*** |
| | (0.12) | (0.07) | (0.02) | (0.05) | (0.16) |
| ln_gr_stock | 0.30 | -0.48 | 3.72*** | 0.01 | 0.92 |
| | (0.21) | (0.89) | (0.67) | (0.66) | (0.87) |
| ln_gdp_cap | -0.09 | 0.22 | -0.39*** | 0.09 | 1.20*** |
| | (0.17) | (0.21) | (0.12) | (0.26) | (0.24) |
| ln_pop_dens | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |
| ln_for_gdp | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |
| _cons | 6.07*** | 8.39* | -15.05*** | 7.72*** | -10.54** |
| | (1.32) | (4.39) | (4.52) | (2.56) | (4.22) |

Many of the estimates of the price coefficients are of wrong sign, both from the models of Hausman-Taylor, FE, GLS and country-specific OLS. The price trends are declining in the period, but the harvest is stable or a little increasing in some countries. The within-variation is much smaller than the between-variation, which may cause weak IV in the Hausman-Taylor models. The FE-estimators are of same reason little efficient.

We have not found many studies dealing with aggregated panel data on timber supply to compare with. Probably, the time trends should be investigated more. Many of the time-series are probably non-stationary, i.e. the mean changes over time, which also can be seen from the graphs. Non-stationarity may lead to estimation problems. This issue has not been investigated in this part of the work, but should be included in any further analysis. In addition, including more variables which may explain more of the differences between countries would be of interest. The two country-specific variables included are for most models highly significant. The difficulties in obtaining positive estimates of price coefficients for FE, RE, Hausman-Taylor and the individual OLS models may be due to the fact that the variation within countries is very small. When changing the time and the panel variables, the estimates change much, as we saw. It is therefore interesting to look at the differences in the estimation. Table 8 and 9 report some key indicators in the estimation of the FE models. The within $R^2$ of the first model is rather low, but very high in the inverse model. A reason for this difference might be the low variation within the countries, but a much larger variation between the countries (within the periods). Both the overall $R^2$ and the value of the F-test indicate that the FE2 model is better suited to the data. The correlation between the country-specific effect (reported as $u_i$) and the explanatory variables is reported to be 0.845 in the first model. In the second, the correlation between $u_i$ (which is now the time-specific effect) and the regressors is less than -0.09.

**Table 8: Indicators of the FE model**

```
Fixed-effects (within) regression               Number of obs      =       244
Group variable:   country                          Number of groups   =        10

R-sq:  within  =   0.2347                          Obs per group: min =        19
       between =   0.8771                                         avg =      24.4
       overall =   0.7924                                         max =        27

                                                   F(4,230)           =     17.64
corr(u_i, Xb)  =   0.8450                          Prob > F           =    0.0000
```

**Table 9: Indicators of the inverse FE (FE2) model**

```
Fixed-effects (within) regression               Number of obs      =       244
Group variable:   year                             Number of groups   =        27

R-sq:  within  =   0.9706                          Obs per group: min =         3
       between =   0.4156                                         avg =       9.0
       overall =   0.9489                                         max =        10

                                                   F(6,211)           =   1160.41
corr(u_i, Xb)  =   -0.0885                         Prob > F           =    0.0000
```

To obtain logical coefficients, several tries of grouping the countries were done. The most succeeded try was the one with following two groups:
South: Austria, France, Germany and Switzerland.
North: Denmark, Finland, Netherlands, Norway, Sweden and UK.

The results are displayed in Table 10. The $R^2$ values are 0.98 and 0.97 for North and South, respectively.

**Table 10: Results of dividing the countries into two groups.**

| | North b/se | South b/se |
|---|---|---|
| ln_log_price | 0.12** | 0.16*** |
| | (0.06) | (0.05) |
| ln_real_rate | 0.16*** | 0.05 |
| | (0.06) | (0.05) |
| ln_gr_stock | 1.06*** | 1.10*** |
| | (0.03) | (0.04) |
| ln_gdp_cap | 0.04 | -0.31*** |
| | (0.10) | (0.06) |
| ln_pop_dens | 0.12*** | 0.00 |
| | (0.04) | (0.05) |
| ln_for_gdp | 0.29*** | 0.36** |
| | (0.07) | (0.15) |
| _cons | 0.31 | 3.63*** |
| | (1.27) | (0.86) |

## Conclusion

The main problem which arises in this estimation is the sign of the coefficients of price in the models with partly and full heterogeneity. Estimation of the partly heterogeneous model showed to be difficult, due to inconsistent estimators and low variation within the countries. Thus, the FE and Hausman-Taylor are not efficient and the GLS/OLS are not consistent. We tried to group the countries to avoid the problem of wrong sign of coefficients in the individual models. In dividing them in two groups, North and South, we obtained mostly logical signs, but the estimates are less significant than in the pooled OLS of the entire sample.

In the model with heterogeneous intercept, most of the dummies showed significance, indicating large heterogeneity as the other indicators. Including more country-specific variables to explain more of the variation of the timber supply between countries would be of great interest. In addition, taking the probable non-stationarity into account can improve the analyses.

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# Conceptual development of cost accounting of wood harvesting in the Republic of Karelia (Russian Federation)

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## Abstract

An improvement in cost accounting (CA) is one of the most important elements of the development of modern logging industry in Russia. CA of wood harvesting is important for management and decision making; it provides necessary information for choosing the optimal method of wood harvesting and for increasing profitability of business. The Soviet method of CA has a long history of development during the whole period of planning economy in Russia.

Nowadays the Nordic machines for wood harvesting play the important role in the Russian wood harvesting development. Cost per machine hour is the important factor for future development of CA in Russia. Nowadays, the Nordic CA method of wood harvesting is an alternative for traditional method. The Nordic approach has been promoted also by making textbooks and leaflets of the CA in forest work with international cooperation.

In this study the general points of Soviet/Russian CA method and Nordic CA method of wood harvesting cost calculation are compared. Both in the Soviet/Russian and Nordic methods wood harvesting costs are divided into fixed and variable costs. The most difference between these two methods is that exchange value of the new machinery is taken into account in the Nordic method, but not in Soviet/Russian method.

**Keywords:** wood harvesting, cost accounting, Russian and Nordic cost accounting methods

## Cost accounting is a key element of Russian logging sector

Cost accounting is the basic element of logging industry development (Fig.1). Cost accounting of wood harvesting plays a major role in management for the process of decision making. Cost accounting provides key information for choosing the optimal method of wood harvesting and increasing of business profitability.

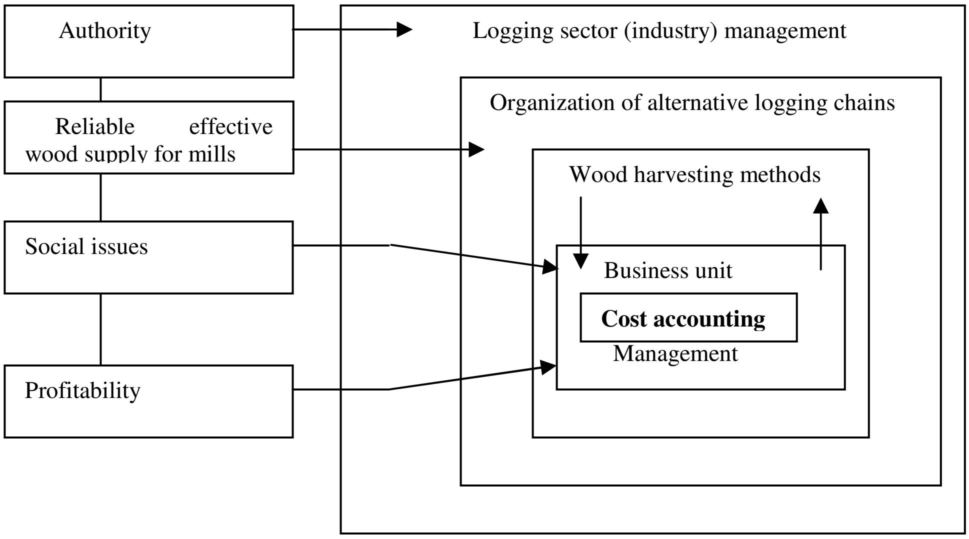


**Figure 1.** The economic elements in wood harvesting

The Soviet/Russian method and principles of cost accounting has been well developed for planning economy. The current domestic *Metodicheskie rekomendatsii po planirovaniyu, uchetu i kalkulirovaniyu sebestoimosti produktsii lesopromishlennogo kompleksa (2003)* has been widely applied in Russia. In 2004, the general principles of Nordic method of wood harvesting cost accounting for Russian conditions were prepared at the Finnish Forest Research Institute (Sikanen et.al, 2004). Improved cost calculation processes for wood harvesting can contribute future wood harvesting to become more cost effective in Northwest Russia.

## Russian cost accounting method in general

The theoretical basis for Russian cost accounting is the Soviet theoretical approach of cost accounting. In the Soviet economy all costs of different types of activity and also cost of logging activity resulted from labour and social production costs (*obshestvennye izderzki proizvodstva*). The value of commercial round wood was composed of labour and other social production costs. Social production costs consisted of three parts. The first part of social production costs was a value of means of production *(stoimost sredstv proizvodstva)*; the second part of social production costs was the value of consumer's goods for itself *(stoimost tovara "dlya sebya")*, and the third part of social production costs was the value of consumer's goods for Soviet society *(stoimost tovara "dlya obshestva").* The cost price of commercial round wood for typical lespromkhoz during the 1950-1960s years of Soviet period could be also calculated such the sum of the first and second parts of social production costs.

Department cost price *( Tsekhovaya sebestoimost )*
+
Overhead cost
=
Production cost price *(Fabrichno- zavodskaya sebestoimost)*
+
Cost of sales
=
Full cost price *(Polnaya sebestoimost)*

↓

Industrial cost price (*Promishlennaya sebestoimost*)

**Figure 2** Main cost price form in planning economy

The cost price had four forms (Fig. 2) that were applied on economic activity of typical lespromkhoz. The first form of cost price was the department cost price (*tsekhovaya sebestoimost)* includes the production cost of the given department for production. The second form of cost price was the production cost price (*fabrichno-zavodskaya sebestoimost)* which included all production cost and added overhead cost. The third form was the full cost price (*polnaya sebestoimost)* which was characterised by total sums of costs not only for production and added cost of the realisation of production. The fourth form was the industrial cost price (*promishlennaya sebestoimost*), which were depended both on the results of the work of the separate logging company, and from the organization of the production on branch as a whole. The cost price was distributed into individual and average industrial logging cost prices. Individual cost price was used for planning in one logging company. The general industrial cost price was the state average cost price. The industrial cost price was the background for price forming which used the products value.

In the USSR the cost accounting, cost price planning and cost price analysis was well developed and widely applied on the economic activity of typical logging companies. The process of cost accounting and cost price planning in logging industry means costs grouping by different economic indicators. There are 5 economic indicators and 10 economic categories were used in planning economy (Table 2).

**Table 2** Main economic indicators and classical categories

| Economic indicators | Economic categories |
|---|---|
| 1. Method of costs distribution | Direct *(pryamiye)* costs |
| | Indirect *(kosvenniye)* costs |
| 2. Economic contests | Prime *(osnovniye)* costs |
| | Burden *(nakladniye)* costs |
| 3. Total wood harvesting volume | Fixed *(uslovno-postoyanniye)* costs |
| | Variable *(peremenniye)* costs |
| 4. Degree of generalization ( *stepen obobsheniya*) | Element *(elementniye)* costs |
| | Integration *(kompleksniye)* costs |
| 5. Using time | Current year *(tekushego perioda)* costs |
| | Future periods *(buduyushikh periodov)* costs |

Source: Chernousov and Sukhanovskiy (1959).

The cost value and distribution mechanism of social manpower were not well developed by the Soviet economic theory in regard to norm method. Sometimes higher costs price has been the basis for higher price. But high real cost were underestimated (long distance in wood transport). This lack of well developed mechanisms, during the period of socialist economy in USSR, has had significant consequences for the current state of national economy. Therefore, the higher of cost price has been the value and price of all goods. The subject of economic theory at the time was rather economic laws than well being of the population.

## Concepts of industrial cost price accounting in planning economy

The nomenclature structure of industrial cost price for logging industry from economic point of view means the spetcific weight of costs including the cost price calculation. Traditionally the industrial cost price are estimated on cost items (6-12) and cost elements (9) , (Fig.3). The cost items has been used for cost control and cost accounting of unit cost of commercial roundwood. The cost standard book (*smeta zatrat)* was a key document in the process of cost price accounting by item. The cost price classification by items was the general part of estimate. Traditionally the industrial or full cost price accounting by method of cost item listed was used for determination of the main calculation economic parameter such as actual *(fakticheskaya)* cost price.

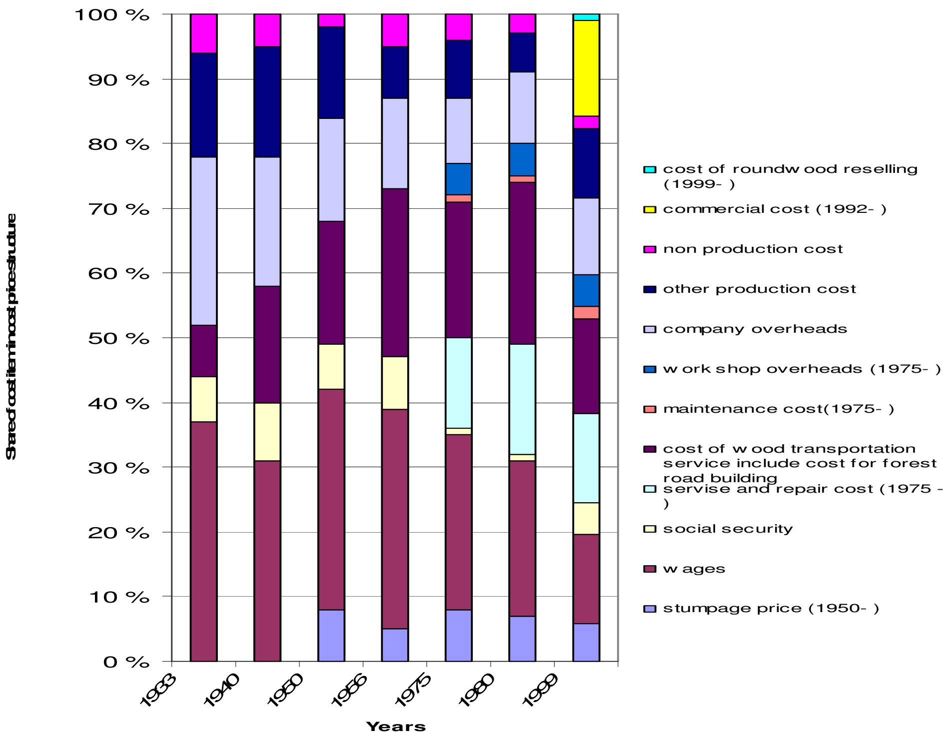


**Figure 3.** Development of structure of cost items, according to the data of Chernousov and Sukhanovskiy (1959) for 1933-1956, Minlesbumprom USSR 1975 and 1980 in Petrov & Morozov (1984) and for 1999 by Styazhkin (2001)

Actual cost price has all attribute of objective truth of economic parameter used for operative management on logging companies and for Soviet taxation system. The quantity of cost items in cost price is changed. Theoretically there was a tendency to continuous simplification and reduction of quantity of cost items included in cost price structure, but in practice the quantity of cost items increased. The sum of total costs of whole lespromkhoz activity has been estimated as cost elements (Fig 4).

In logging industry has been used the spetcific work quota for systematic cut of branch cost price duringmany decads of Soviet period. The key method of gradual rasing of the rate of costs has been used for cost price accounting.

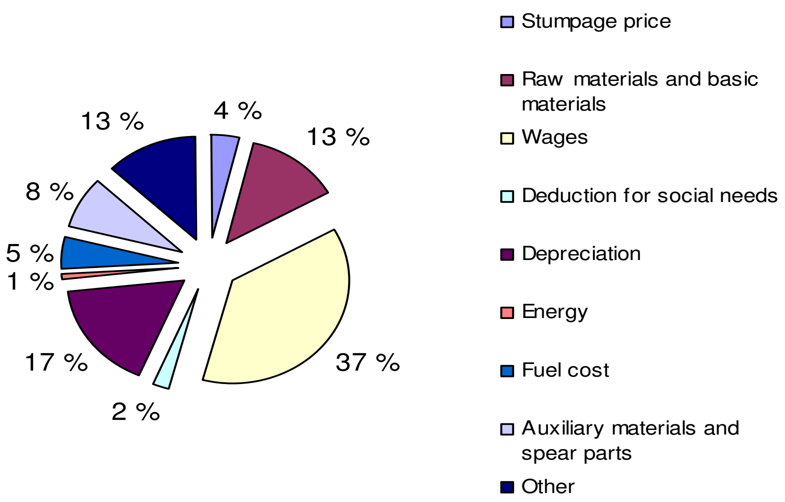


*Figure 4* ***Standard cost elements of industrial cost price for logging industry and they relative weight according data Minlesbumprom USSR 1980 modified (Petrov & Morozov (1984).***

## Changes in cost accounting during the became of market economy

In the period of economic reform in Russia from 1992, the subject of economic theory was changed. In the Russian forest sector the current economic theory studies customers behaviour and production efficiency for pricing products, with a target of accessing maximum profit within the conditions of current limited forest resources.

Transition period from 1992 to 1999, Russian model of market economy for whole Russian forest sector and especially for logging industry development was complicated and difficult. The idea of Soviet economic mechanism for full or industrial cost price cutting had been imperfect. Industrial cost price has been increasing continuously and Western methods of management accounting and financial accounting were not accepted by Russians logging industry economists.

During period of becoming *(stanovleniya)* market economy from 1999, the intensity of capitalization of logging companies has been increased (Fig.5).

For logging companies, especially in the Republic of Karelia, firstly were changed dominate method from traditional whole tree or tree-length method of wood harvesting to the cut-to-length. Secondly, logging companies have started to operate under a new forest owner's leadership (*lesopolzovatel*) status. In 2006, the main *lesopolzovatel* in the Republic of

Karelia was JHC “Karellesprom”. Thirdly, new models of Nordic machinery are coming to use through leasing.

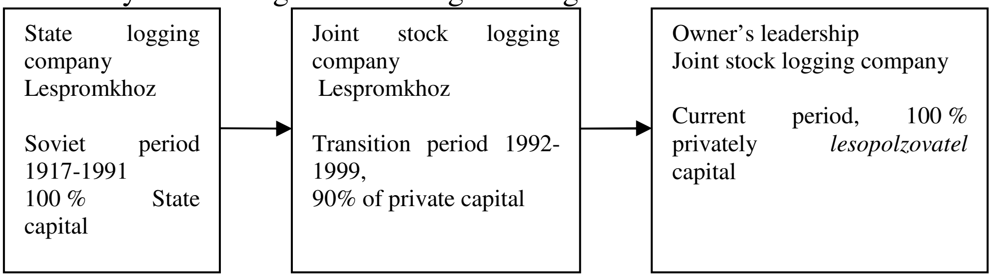


**Figure 5.** Theoretical chain of a new role of logging company.

For Republic of Karelia conditions the most common leasing repaying scheme was as follows. The first payment in 2006 was not more than 25% of the machine purchase price, every quarter an equal sum is paid according to the leasing contract and also leasing interest more than 10% per every leasing year. In 2006 the share of leasing cost was 40% from wood harvesting costs for CTL method of wood harvesting, which using Nordic machinery. The depreciation costs have increased considerable. The current “attitude” to cost price has changed. The calculation parameter of factual cost price on logging companies has a character of top commercial secret and it is interpreted as a taxation attribute and has varies greatly in different logging companies. The quantity of cost elements in structure of industrial cost price has been decreased from 9 to 5, but quantity of sub-elements has been increased and costs become more integrated (Tabl.3).

**Table 3** Development of the order of cost elements in the structure of industrial cost price

| Cost element structure since 1992 | Integrated cost element structure 2003-2008 |
|---|---|
| 1. Stumpage price | 1. Material costs *Materialniye raskhody* |
| 2. Raw materials and basic materials | |
| 3. Wages | 2. Wages *Raskohody na oplatu truda* |
| 4. Deduction for social needs | |
| 5. Depreciation | 3.Unit social tax *Ediniy sosialniy nalog* |
| 6. Energy | |
| 7. Fuel cost | 4. Sums of depreciation *Summy nachislennoy amortizatsii* |
| 8. Auxiliary materials | |
| 9. Other | 5. Others *Prochiye* |

The concept and general elements of Western market economy are currently having an increasing effect on the Russian economics theory. The management accounting is one of the four approaches of modern Western cost accounting theories. The management accounting is the alternative of traditional method of cost accounting. From the economic point of view, the current strategy of large scale logging companies in the Republic of Karelia is the increasing of wood harvesting profitability. There has been a follow-up of the profitability of wood harvesting in Soviet Union and then in Russia since 1999. During the last five years wood harvesting has in general been unprofitable in Russia in period 2001-2005. The wood harvesting cost and price dependent demand limits the real economic capacity of harvesting. In reality many traditionally run Russian logging companies operating in the Republic of Karelia have not reached appropriate profit levels since the start of economic reform, and have thus suffered considerable operational losses. However, this situation has not followed the pattern of unfavourable market conditions. Due to the increasing demand of forests for alternative uses and products, which will limit harvesting volume, it is crucial for the Russian logging.

The current limitations on forest resources and harvesting in the Republic of Karelia require optimal harvesting technology and therefore more sophisticated methods for cost calculation. Now with Nordic technology the capital cost is that high that profitability depends on harvesting volume. In practise, the current harvesting cost distribution into fixed cost and variable cost still has some elements of the characteristics and rating factors from the previous system used during Soviet times.

## Development of Nordic cost accounting method for wood harvesting

Nowadays the Nordic machines for wood harvesting play the important role in wood harvesting development. Cost per machine hour is the important factor which need used for wood harvesting cost calculation and for cost price calculation. The Western approaches have been promoted also by making textbooks and leaflets of the cost accounting in forest work with international cooperation (Sikanen et al. 2004, Ananyev et al.2005).

**Table 4** Some differences in cost accounting of wood harvesting between domestic and Nordic CA methods

| Domestic cost accounting method | Nordic cost accounting method |
|---|---|
| Three-length method of wood harvesting and domestic machinery have been applied | Cut-to-length method of wood harvesting |
| Domestic machinery and common form of logging work organization was *kompleksnaya brigada* and one working shift | New Nordic machinery for logging companies in Russia |
| 7-hours working shift in cutting area | Working team and 24-hours working in cutting area |

Source: Tyukina 2000, 2001, 2004 and 2007

The methodical concept of sales price accounting for independent logging companies can be described such as the “tree of costs” (Fig.6) form consisting of three cost levels. The first level of costs includes the cutting area costs, round wood transportation costs and average stumpage value. Cutting area costs is the total costs of round wood harvesting on cutting area. Transportation costs is a costs of round wood transportation from roadside terminal or upper landing to lower landing and than to mill gate or directly to mill gate. Average stumpage value is a specific cost included two types of payments. The first part is the payment of value for commercial wood that was used for wood harvesting. The second part is reflected the value of forest land through the forest rent in the form of tax rate for rent of forest land.

The sum of cutting area costs and round wood transportation costs form the second level of costs so called wood harvesting cost. Overheads, wood harvesting cost and average stumpage value form the procurement cost.

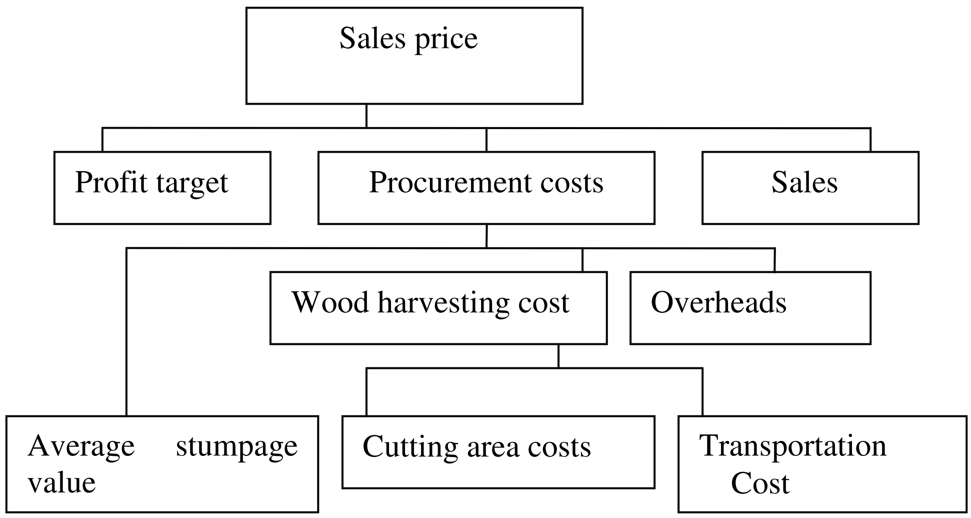


**Figure 6.**The general framework of cost and sales price accounting for new independent logging company.

Cost of sales can be established on the third level and calculated as a total sum of costs, which arise during the sales of short round wood to customers. The sum of procurement costs, costs of sale and profit target form the sales price.

## Conclusions

- Nordic method of wood harvesting cost accounting is necessary element for economic terminology development and bringing together Western and Russian views in forest economics.
- Soviet cost accounting has a specific status in the history of cost accounting in the World.

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# Risk Preferences, Risk Perceptions and Timber Harvest Decisions – An Empirical Study of NIPF Owners in Northern Sweden

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## Abstract

A mail survey of NIPF owners in two counties in northern Sweden was conducted to investigate the risk preferences, perceptions of the return and risk of timber investment relative to investment alternatives outside forestry. Our aim was to determine to what extent the NIPF owners' harvesting behaviour was consistent with their preferences and subjective judgments.

A majority of the respondents were risk-neutral or risk-prone. We found that risk preferences have significant impacts on the decision to fell; the more a forest owner likes to take risks, the more likely it is that he/she conducts final felling. The result also shows large variations among NIPF owners with respect to the subjective judgements of the return and risk of the alternative investments.

For each respondent we elicited the most preferred investment alternative based on the stated risk preferences and the subjective judgements of the return and risk of the alternative investments. Owners whose preferred investment alternative is the mature forest are on average significantly less active in harvesting than owners with other preferred investment alternatives. The study reveals indications of the difficulties for NIPF owners to make rational decisions when faced with uncertainties.

**Keywords**: Risk-preference; Risk-perception; Subjective judgement; Felling decision; Consistency; Preferred investment

## 1. Introduction

The knowledge of optimal forest management under uncertainty has accumulated rapidly during the last three decades. Since the 1980s a large number of studies have been conducted to determine optimal forestry decisions when the management outcome is uncertain. Sources of uncertainty that have been addressed include the risk of forest destruction due to wildfire, forest damages caused by e.g. insects and storm, the result of forest regeneration efforts, random variations in forest growth, unexpected fluctuations in stumpage price and interest rate, etc.. Two categories of models have been developed to formally incorporate uncertainty into the analysis of forestry decisions. The first category consists of the so-called anticipative optimization models, which are constructed to determine the optimal management program (i.e. the time schedule of management activities) during an entire rotation period or a given time horizon. Examples of anticipative forestry decision models include Reed (1984), Hogansson and Rose (1987), Caulfield (1988), Gassman (1989), Hof and Pickens (1991), Taylor and Fortson (1991), Valsta (1992), Armstrong (2004).

The second category of models, commonly known as adaptive optimization models in the forest economics literature, are designed to determine the decision rules that specify the optimal management option at each point in time conditional on the then observed values of the relevant stochastic variables. Adaptive optimization models have been developed primarily for determining the final harvest time in even-aged stand management with stochastic timber prices (see e.g. Lembersky and Johnson, 1975; Norstrom, 1975; Risvand, 1976; Lohmander, 1987; Brazee and Mendelsohn, 1988; Haight and Smith, 1991; Gong 1999; Brazee and Bulte, 2000; Insley and Rollins, 2005). Adaptive decision models have also been developed for uneven-aged stand management and for silvicultural decisions under uncertainty (Kaya and Buongiorno, 1987; Lin and Buongiorno, 1998; Jacobsen and Helles, 2006).

Stochastic forestry decision models (anticipative as well as adaptive) have been tested in numerous case studies. These studies have not only demonstrated how to include uncertainties from different sources in forestry decision analysis, but also shown the importance of doing so - in most cases, the incorporating of uncertainty could lead to significantly superior decisions than when uncertainties are ignored. Despite that, it is unclear to what extent stochastic optimization models are applied to incorporate uncertainties in real world forest management. For example, statistics about timber prices and the total harvest volume in Sweden during the past years (Skogsstyrelsen, 2007) show no indication of wide-spread application of the adaptive harvest decision model under conditions of price uncertainty[11].

There are many possible reasons why a forest owner would not turn to a stochastic decision model when choosing among different management options. One reason could be the lack of knowledge about stochastic decision models. Another reason might be that the forest owner does not believe that the existing stochastic models properly describe his/her decision problem. Most of the stochastic decision models maximize the expected net

[11] Application of the adaptive harvest model by a large number of forest owners would lead to a significant increase in the price elasticity of timber supply and to diminishing random variations in timber price in the short-run (Gong and Löfgren, 2007).

present value (NPV) of the cash flow associated to forest management, where the present value is calculated using a deterministic (risk-free) discount rate. Maximization of the expected NPV and the use of a deterministic discount rate are both motivated by the assumption of risk-neutral preferences. A forest owner who values non-market priced benefits of the forest and/or is not risk-neutral may have difficulties to see the relevance of such models. With a single forest stand, one can modify the expected NPV maximization objective to address non-neutral risk preferences or to accommodate the non-market priced benefits (see e.g. Gong, 1998; Gong et al., 2005). However, a forest owner typically owns multiple forest stands, and non-neutral risk preferences or concerns about non-market priced benefits typically make the management decisions for different stands interdependent.

There is no doubt that many forest owners are not risk-neutral. Theoretical analyses of timber harvest decisions of risk-averse forest owners show that the optimal harvest level depends on, among other things, the degree of risk-aversion, the forest owner's position in the capital market, and the relative risks of investments in and outside forestry (Ollikainen, 1993; Gong and Löfgren, 2003; Alvarez and Koskela, 2006). Intuitively, the optimal decision would also depend on the degree of uncertainty of investment in forestry relative to investments outside forestry in cases where the forest owner is risk-prone. Many studies have assessed the expected return and risk of investment in forestry (Redmond and Cubbage, 1988; Binkley et. al., 1996; Penttinen and Lausti, 1999; Lönnstedt and Svensson, 2000; Sun and Zhang, 2001; Lausti, 2004; Lundgren, 2005). It should be pointed out that the return of forestry investment examined in most of these studies was calculated based on restrictive assumptions about forest management decisions. One typical assumption is that timber harvest equals growth on an annual basis, or a forest stand is harvested once it reaches a fixed rotation age. It is obvious that forest owners should not rely on results from this type of studies when determining how to manage their forests in the presence of uncertainties.

Presumably, most forest owners pay attention to uncertainties in forestry decisions. However, many of them do not adopt any formal procedure to incorporate uncertainties in decision-making. This means that the subjective judgements of forest owners about the relative uncertainties of investments in and outside forestry play a key role in their choices among forest management alternatives. Furthermore, without following a formal procedure to incorporate uncertainties, the management behaviour of a forest owner could very well differ from what a theoretical analysis would suggest.

The purposes of this paper are 1) to investigate the risk-preferences of non-industrial private forest (NIPF) owners and their perceptions of the return and risk of timber investment as compared to alternative investments outside forestry; and 2) to examine the relationship between the stated preferences, subjective judgments, and the observed and planned timber harvests. Knowledge about NIPF owners' preferences and their perception of the return and risk of different investment alternatives is essential for improving the understanding of their forest management behaviour. More importantly, such knowledge would make it easier to identify effective means to assist NIPF owners in making rational decisions. Many empirical studies have found statistically significant correlations between some NIPF owner characteristics and the harvest level (see Amacher et al. 2003 for a review). The investigation of the risk-preferences of NIPF owners and their perceptions of the return and risk of different investment alternatives will contribute to improving the understanding of the mechanisms through which owner characteristics affect management behaviour. With the examination of the relationship between the preferences, subjective judgments, and timber harvest activities/plans, our aim is to determine to what extent NIPF owners' management behaviour is consistent with their preferences and judgments.

## 2. Method

### 2.1. Study area and sample

A mail survey was sent to NIPF owners in the counties of Västerbotten and Västernorrland in northern Sweden. Both counties are located in the boreal zone (Ahti et.al. 1968) and have their eastern border at the Baltic Sea. Their western borders are however different. The county of Västerbotten reaches all the way to the Norwegian border in the west, while Västernorrland reaches roughly half as far to the west, see Figure 1.

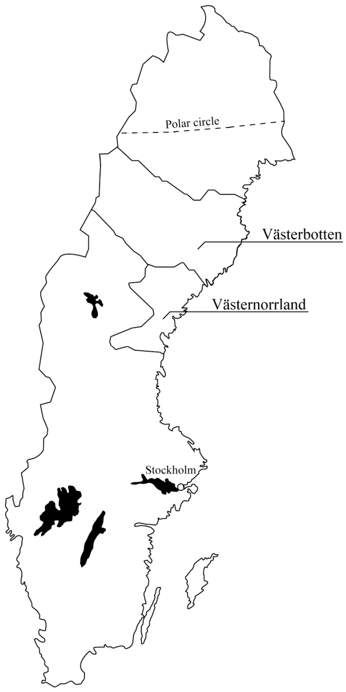


*Figure 1. Map of Sweden, with the location of the study area.*

The western part of northern Sweden is dominated by mountains and the productivity of the land is comparatively low. It can hence be expected that, when comparing mean values for Västerbotten and Västernorrland, the latter shows higher timber stocks. In Västerbotten there are around 20,250 NIPF holdings[12] and 43 % of the forest land is owned by NIPF owners. In Västernorrland there are around 14,100 NIPF holdings and 43.4 % of the forest land is owned by NIPF owners (Skogsstyrelsen, 2007). Some characteristics of the forest land in the two counties and of the whole of Sweden are presented in Table 1. At the national level, 51 % of the forest land is owned by NIPF owners (Skogsstyrelsen, 2007). The total area of forest land in the two counties is nearly 5 million hectares and account for 21.3 % of all forest land in Sweden. Looking at the fellings in each of the counties, the NIPF accounted for 39.9 % of the total area reported for final felling in Västerbotten in 2006, and in Västernorrland the corresponding share was 46.8 %. In the period 2003-2005 the annual gross felling on NIPF land in Västerbotten was 3.1 million cubic meters or 41.7 % of the total volume felled in the county. For the same period, 3.0 million cubic meters, or 48.3 % of the total volume felled in Västernorrland came from NIPFs.

[12] The number is an approximation based on taxation units. A NIPF holding refers to an estate owned by private persons, including deceased persons.

Together the two counties accounted for 6.3 % of the fellings in Sweden in the period 2003-2005 (Skogsstyrelsen, 2007).

*Table 1. Forest land, timber stock (averages for 2001-2005) and annual fellings (average for 2003-2005)in Västerbotten, Västernorrland and Sweden in total. Shares (%) of the total in parentheses. Source: Skogsstyrelsen, 2007.*

| | | Västerbotten | Västernorrland | Sweden |
|---|---|---|---|---|
| Forest land ($10^3$ of ha) | NIPF | 1,366 (43.0) | 753 (43.4) | 11,758 (51.0) |
| | Public, companies | 1,814 (57.0) | 982 (56.6) | 11,281 (49.0) |
| | Total | 3,180 | 1,735 | 23,039 |
| Total stock ($10^6$ of $m^3$) | NIPF | 140.7 (46.7) | 118.2 (48.8) | 1,728.4 (57.6) |
| | Public, companies | 160.8 (53.3) | 124.0 (51.2) | 1,271.2 (42.4) |
| | Total | 301.5 | 242.2 | 2,999.6 |
| Stock of timber ($m^3$/ha) | NIPF | 103 | 157 | 147 |
| | Public, companies | 88 | 126 | 112 |
| | Total | 95 | 140 | 130 |
| Fellings ($10^6$ of $m^3$) | NIPF | 3.121 (41.7) | 3.034 (48.4) | 61.192 (62.8) |
| | Private companies | 2.415 (32.3) | 3.116 (49.7) | 24.443 (25.1) |
| | State and other public | 1.942 (30.0) | 0.115 (1.8) | 11.865 (12.1) |
| | Total | 7.478 | 6.265 | 97.500 |

Forestry is important in the Swedish economy, and with the large share of NIPF lands the NIPF owners play a key role. In 2005 nearly 19 million hours of work were conducted in Swedish small-scale forestry. In total around 100.000 persons were employed in forestry, the wood manufacturing industry and the pulp- and paper industries in 2005 (Skogsstyrelsen, 2007). The value of all production in the forestry sector in 2004 was estimated to 185 billion SEK. The value of exports of timber and forest industry products was 12.2 % of the total value of exports and 4.3 % of GDP (Skogsstyrelsen, 2007).

For each of the two counties, addresses to NIPF owners with an area of forest of 25 hectares or more were obtained from the Swedish Forest Agency. Owners of properties of less than 25 hectares were excluded since it was expected that such properties had little potential of having economic significance to its owners. A pre-test was conducted on 100 NIPF owners in the county of Västerbotten and after adjustments the full scale survey of 2,000 questionnaires (1,000 in each of the two counties) was sent in February 2007.

### 2.2 The survey

The mail survey had four parts with different focuses and a total 40 questions. The first part was demographic information such as the age and gender of the respondents, as well as the importance of forestry income. The second part concerned the respondent's management objectives, attitudes towards risk and his/her judgement of the return and risk of forest investment and non-forest investments. For the purposes of this study it is important to establish whether the respondents have economic objectives or not. For owners without economic objectives it is irrelevant to elicit their attitude towards risk and their preferred investments. One part of the survey was focused on the felling activities during the period 2001-2006 and felling plans for the coming three years (2007-2009). This line of information was to be used for determining the effect of risk preferences on the felling behaviour. It was assumed that 6 years was a reasonably short period for the forest owner to correctly recall, or recollect, the desired information, yet long enough to get a reasonable amount of observations on fellings (in the area studied, owners of small properties may not even make final fellings in each decade). The future period was chosen shorter since is was assumed that the felling decisions, as well as the motivations for felling, would be hard to overview in detail for any longer period. In this survey, focus was on final fellings only and did not include thinning or clearing. This was explicitly explained to the respondents. The final part of the survey consisted of questions about the possession, use and evaluation of forest management plans. The aim of the questions about management plans was to evaluate to what extent such tools are used and how much they effect the felling decisions of the NIPF owners.

## 3. Results

### 3.1. The respondents

After sending one reminder the final response rate ended up at 52.6 %. There was no significant difference between the two counties concerning the response rate. Descriptive statistics of the respondents are shown in table 2. In total about one third of the respondents were women. The share of female respondents from Västernorrland was significantly higher than from Västerbotten. According to official statistics, 38.6 % of the NIPF owners in Västernorrland and 36.1 % of the NIPF owners in Västerbotten are women (Skogsstyrelsen, 2007). The lower share of women from Västerbotten is however not extreme and is not expected to affect the reliability severely. The respondents were asked to state their main occupation and these results are also shown in Table 2. Ownership length was significantly longer in Västerbotten. The average number of owners on each property was for

Västerbotten in line with official statistics, 1.7 owners in the survey and 1.6 owners according to statistics (Skogsstyrelsen, 2007). For Västernorrland, however, the result from the survey is significantly higher than the official statistics, 2.2 owners in the survey and 1.5 according to the statistics (Skogsstyrelsen, 2007). The reason for this difference for Västernorrland is unclear. In Västernorrland significantly more NIPF owners were also members in a NIPF owners association, compared to Västerbotten. Overall, a large share of the respondents had either a permanent or a leisure home on their forest property.

*Table 2. Descriptive statistics of the respondents.*

| | Västerbotten | Västernorrland | Total | Standard deviation |
|---|---|---|---|---|
| Response rate (%) | 54.7 | 50.5 | 52.6 | |
| Share of females/males (%) | 25.0*/75.0* | 34.6*/65.4* | 29.6/70.4 | |
| Mean age (years) | 59.7 | 59.1 | 59.4 | 11.9 |
| Number of persons in household[a]/persons younger than 20 years | 2.4/0.49 | 2.4/0.49 | 2.4 /0.49 | 1.08/0.93 |
| Occupation[b] (% of respondents) | | | | |
| Employed | 47.0 | 47.1 | 47.1 | |
| Retired | 38.8 | 34.5 | 36.7 | |
| Farming/Forestry | 9.1 | 11.9 | 10.5 | |
| Other business | 8.4 | 10.5 | 9.4 | |
| Other occupation | 2.9 | 3.0 | 3.0 | |
| Length of ownership (years) | 24.1* | 21.9* | 23.0 | 12.9 |
| Number of owners | 1.7* | 2.2* | 2.0 | 1.7 |
| Membership in NIPF owner association (%) | 55.3* | 68.2* | 61.5 | |
| Home (permanent or leisure) on property (%) | 78.6 | 75.4 | 77.1 | |

* Indicates statistical significance at the 5 % level of confidence.
[a] Households of more than five persons are counted as five persons.
[b] Some respondents state more than one occupation which results in shares of more than 100 percent in total.

### 3.2. The NIPF properties

The mean land area of the NIPF holdings was 248.9 hectares of which 177.4 hectares[13] were productive forest land. The mean stock of timber on the properties was around 15,630 $m^3$ and the mean stock of timber per hectare was 91.6 $m^3$ (see Table 3). As can be seen in the table, the NIPF owners in Västerbotten had slightly larger properties in total, but somewhat smaller areas of productive forest land and smaller mean stocks of growing timber compared to the owners in Västernorrland. The difference was

[3] Productive forest land is defined as the land with a MAI of1 $m^3$/ha/yr or higher with normal management intensity.

probably due to the different locations of the two counties as mentioned in the *method* section.

*Table 3. Characteristics of the respondents´ properties.*

| | Västerbotten | Västernorrland | Total |
|---|---|---|---|
| Total land area (ha) | 251.4 | 245.9 | 248.9 |
| Area of productive land (ha) | 176.0 | 179.0 | 177.4 |
| Stock of timber per ha ($m^3$) | 81.5* | 103.9* | 91.6 |

* Indicates statistical significance at the 5 % level of confidence.

For both counties, the mean stock of timber according to the survey, was less than the mean stock on NIPF land according to the National Inventory of Forestry; 103 $m^3$/ha in Västerbotten and 157 $m^3$/ha in Västernorrland (Skogsstyrelsen, 2007). In this survey, the respondents were asked to state the volume of their forests. Some of them, it can be assumed, stated quite accurate figures, based on recent inventories, while others probably stated older figures or figures based on their best guesses. Plausible reasons for underestimating the stock of a property are that inventory data were old and recent growth was not accounted for, or the owner considered only older stands when answering the question about total stock.

### 3.3. Management objectives

A NIPF owner typically has several objectives associated to the ownership and management of his/her forest. Moreover, there are large variations among different NIPF owners in the set of and in particular the ranking of objectives (e.g. Carlén, 1990; Berlin et al., 2006). Theoretically, how a NIPF owner manages his/her forest depends to a large extent on the main objectives. Economic return and risk are relevant only if the forest owner actively manages the forest to obtain economic benefits. In order to form a picture of the ownership/ management objectives of NIPF owners in the study area, we asked in the survey each respondent to specify the three most important objectives of owning/managing the forest. A list of eight objectives was provided in the questionnaire. A respondent could choose from the list and/or specify any other objectives which he/she considered important.

Table 4 presents the objectives listed in the survey, together with the share of respondents who choose each of the objectives. The item “Other objectives” in Table 4 consists of all the objectives specified by the respondents. The survey shows that nearly 56 % of the respondents chose “economic contribution to the household” as one of their most important objectives. This figure is very close to the results of two earlier surveys of

NIPF owners' ranking/valuation of the benefits of forest ownership in Sweden (Carlén, 1990; Berlin et al., 2006).

*Table 4. NIPF owners' objectives of ownership. Share of respondents who stated each objective as one of their objectives.*

| Objective | Share of respondents (%) | Active | Objective | Share of respondents (%) | Active |
|---|---|---|---|---|---|
| Economic contribution to the household | 55.8 | 67.4* | Amenities around residence | 24.7 | 50.2* |
| Keeping forestry tradition of the family | 61.1 | 59.4 | Conservation of biodiversity | 15.1 | 55.0 |
| Hunting opportunities | 29.4 | 56.3 | High timber stock | 29.1 | 72.9* |
| Recreation (other than hunting) | 24.5 | 45.4* | Other objectives | 6.6 | 56.5 |
| Quality leisure time activities | 33.8 | 59.7 | All with stated objectives | | 58.1 |

* Indicates statistical significance at the 5 % level of confidence.
[a] $m^3$ per hectare of productive forest land.

A majority of the respondents (61 %) stated that keeping the tradition of forestry within the family is one of the most important objectives. Carlén (1990) reported that about 25 % of the NIPF owners who responded to his survey chose the opportunity of keeping forestry tradition as one of the three most important benefits of forest ownership. Berlin et al. (2006) reported that 50 % of the respondent indicated that keeping forestry tradition was important or very important. In addition to the opportunity of keeping forestry tradition, the earlier surveys included another category of directly related benefits[14] which is not found in the list of objectives presented in our questionnaire. The respondents in our survey may have interpreted the objective "keeping forestry tradition" in such a way that it includes keeping contacts with native location and with relatives and friends. This is most likely the reason why this survey shows a larger share of the respondents who considered keeping forestry tradition as an

[14] Named "opportunity of keeping contacts with native location and with relatives and friends" (Carlén, 1990), or "maintain contact native locality" (Berlin, et al. 2006).

important objective. For each objective, the column Activity in Table 4 shows the share of all the owners with that objective that had been active in final fellings. It can be seen that NIPF owners with the objectives of economic contribution to the household and high timber stock had been significantly more active in fellings and that owners with the objectives recreation and amenities around the residence had been significantly less active in final fellings.

The share of the respondents who chose maintaining hunting-opportunities as one of the three most important objectives (29 %) is similar to what was reported in the other two studies (Carlén, 1990; Berlin et al., 2006). The shares of respondents who chose "recreation", "quality leisure time activities" and "amenities around residence" are 25 %, 33 %, and 25 %, respectively. In the survey reported in Carlén (1990), about 15 % of the respondents included "open air activities" in the three most highly ranked benefits from the forest. Berlin et al. (2006) showed that about 55 % of the respondents considered "outdoor life and recreation" important or very important benefits of forest ownership.

In the questionnaire we listed biodiversity conservation as one of the potential objectives the respondent could choose. Only 15 % of the respondents indicated that this is one of the three main objectives for them to own/manage the forest. In contrast to this, 29 % of the respondents selected high timber stock as one of the three most important objectives. From our personal experience we knew that there were NIPF owners in Sweden who were resolute in their efforts to build up a large growing stock of timber that can hardly be justified by a standard forest economics analysis. Some of the owners believe that timber assets are much more secure than financial assets. Some owners believe that a large growing stock of timber is an important indicator of good forest management. As to this survey, it is also possible that some of the respondents selected high timber stock as one of the main objectives because they consider that increasing the growing stock of timber is an important means to achieve some other objectives.

The results show that the overall structure of NIPF ownership/management objectives in Västerbotten and Västernorrland are similar to that for the whole country. Practically all NIPF owners own/manage their forests for multiple purposes. Income from forestry is one of the benefits that are highly prioritized by over half of the NIPF owners. Moreover, it should be emphasized that the other objectives, perhaps with the exception of biodiversity conservation, are to some extent compatible with the objective of making profits from the forest through timber production. This means that, for a majority of the NIPF owners, it is important to consider the return and risk of timber investment when making decisions on the management of their forests.

### 3.4 Timber harvest

For the convenience of expression, we will from here on refer to those NIPF owners who conducted final felling during the period 2001-2006 as *active owners*, and those who did not make any finial felling will be called *inactive owners*. It should be emphasized that here we are focusing on the final felling. An owner who is classified as inactive could very well have been active in conducting other forest management activities.

For the whole sample, 58.1 % of the respondents were active. On average, each active owner harvested 2,426 $m^3$ during the period 2001-2006. From Table 5 it can be seen that the active owners had a significantly larger area of productive forest land than the inactive owners. Interesting to note is that even though the active owners have conducted felling in the period 2001-2006 they have a larger mean growing stock of timber per ha than the inactive owners. Also, active owners are to a larger share members of NIPF owners associations than inactive owners.

*Table 5. Property characteristics for the active and inactive groups. Fellings of the active group and shares of owners in NIPF owner association. Standard deviation in parenthesis.*

| | Active | | Inactive | |
|---|---|---|---|---|
| Area of productive land (ha) | 212.0* | (434.5) | 105.1* | (103.5) |
| Stock of timber ($m^3$/ha) | 94.1 | | 87.8 | |
| Membership in NIPF owner association (%) | 69.9* | | 54.4* | |

* Indicates statistical significance at the 5 % level of confidence.

Table 6 shows the main reasons the active owners in the respective counties for deciding to make final felling during 2001-2006. Three options were presented in the questionnaire, and each respondent was allowed to give more than one reason. The most common reason for conducting final felling was that *Stands were mature*. For the whole sample, 73.4 % of the active owners stated that this was one of the main reasons for conducting final felling during the period 2001-2006. A larger share of owners in Västernorrland motivated their harvest by this reason than in Västerbotten. Of the active owners in the two counties nearly 22 % stated that they conducted final felling because of the *Need for capital*. The share of owners in Västernorrland who gave this reason is significantly lower than in Västerbotten. That final felling was made in accordance with their forest management plans[15] was stated by 18.7 % of the active owners. The share of active owners who harvested for other reasons is 7.8 %. Examples of *other reasons* for having made felling include: coordinated harvesting with neighbouring estates, and to prevent or salvage after damages.

*Table 6. The main reasons stated by the active owners for having conducted final fellings. Figures show shares (%) of active owners stating each reason.*

| | Västerbotten | Västernorrland | Total |
|---|---|---|---|
| Fellings made according to forest management plan | 19.4 | 17.9 | 18.7 |
| Mature stands | 69.8 | 77.1 | 73.4 |
| Need for capital | 25.4 | 18.7 | 21.8 |
| Other reasons | 7.5 | 8.1 | 7.8 |

The main reasons why the inactive owners did not make final felling are presented in Table 7. About one fourth of the inactive owners did not make any final felling in the period 2001-2006 because of the lack of mature stands. One third of the owners have mature stands which they have chosen to leave unharvested because they considered the standing timber stock was the best investment alternative. There are no significant differences between the two counties in the reasons stated by the inactive owners to why they have not made final fellings.

[15] A forest management plan contains details of the forest stands and recommendations of management decisions.

*Table 7. Main reasons for not having conducted final fellings. The table shows shares (%) of inactive owners stating each reason.*

| | Västerbotten | Västernorrland | Total |
|---|---|---|---|
| No mature stands | 22.6 | 28.2 | 24.9 |
| Prohibited by law | 1.8 | 2.7 | 2.1 |
| Upcoming shift of ownership | 13.1 | 10.1 | 11.9 |
| Stand(s) regarded as best investment in the period | 33.9 | 32.9 | 33.5 |
| Stand(s) has aesthetical or recreational values | 14.9 | 20.1 | 17.0 |
| Other reasons | 19.9 | 15.4 | 18.1 |

The respondents were also asked about their felling plans for the coming three years. Of the respondents, 46.5 % stated that they will harvest in the coming three years, 46.1 % stated that they will not, and 7.4 % were uncertain. There was a significant difference between the group of active owners and the group of inactive owners in the harvest plan for the coming three years. As Table 8 shows, slightly more than 50 % of the active owners planned to fell in the coming years, which is significantly higher than the share of inactive owners who had a plan to conduct final felling. Looking at the active group and comparing Table 8 with Tables 6 and 7, one can see that the reasons for planning to fell or planning not to fell in coming years are similarly distributed as the reasons for having felled or not having felled in period 2001-2006.

*Table 8. The respondents' plans to fell and plans not to fell, and the reasons for the respective plans.*

| | active | inactive |
|---|---|---|
| Plans to fell | 51.7* | 38.7* |
| Why plan to fell? | | |
| Time to fell according to management plan | 20.8 | 21.3 |
| Stands are mature | 71.2 | 67.1 |
| Need for capital | 17.7 | 11.6 |
| Other reason | 9.4 | 8.4 |
| Plans not to fell | 39.7* | 59.4* |
| Why plan not to fell? | | |
| Stand(s) best investment in coming period | 33.7 | 28.2 |
| Prohibited by law | 1.5 | 1.6 |
| Upcoming shift of ownership | 24.8 | 17.6 |
| No mature stands | 18.8* | 28.2* |
| Stand(s) has aesthetical / recreational values | 19.3 | 20.7 |
| Other reasons | 8.4 | 11.7 |
| Don't know if to fell | 8.6 | 11.6 |

* Indicates statistical significance at the 5 % level of confidence.

### 3.5 Attitudes toward risk

The survey contained two questions aimed to elicit information about NIPF owners' attitudes toward uncertainty in the monetary gains from forestry. The questions were formulated as follows:

Suppose that you have decided to carry out a final felling and sell the timber next year. Based on the timber prices in the past 10 years you have estimated that the market price of timber next year will fall in the interval 360-440 SEK/$m^3$ and the expected timber price is 400 SEK/$m^3$. Now, a timber buyer offers to buy your timber at a fixed price of 400 SEK/m$^3$, to be paid when the harvest takes place one year later. You can either accept the offer, which means that you will receive a sure price of 400 SEK/m$^3$ for the timber felled next year, or wait to sell the timber at the prevailing timber price which lies in the interval 360-440 SEK/m$^3$.

> Question A: Would you prefer to accept the offer of a fixed price of 400 SEK/m$^3$, or would you rather wait and sell at the prevailing market price next year?
> Question B: If you can negotiate with the timber buyer on the fixed price, what is the lowest price you would require for agreeing to sign a contract and fix the price today?

The respondents were asked to answer question A by checking one of four alternatives: accept the offer, wait and sell at the market price, indifferent between the two alternatives, or do not know. Based on the answer to the first question, the respondents were divided into four groups: risk-averse, risk-neutral, risk-prone, and unsure owners. The group of risk-averse owners includes those who prefer to accept the offer and thereby avoid uncertainty in the harvest revenue. Risk-neutral owners are those who are indifferent between the two options. The third group, risk-prone owners, consists of those who prefer to wait and sell at the market price next year. The unsure group includes all respondents who stated that they did not know which of the options was better. An intuitively reasonable interpretation of such an answer is that the two options appeared to be almost equally desirable to the respondent, which means that a respondent who is unsure which of the options he/she prefers is risk-neutral. There are, however, other possible reasons why a respondent could not decide which option he/she prefers, and hence a respondent who did not know which was the preferred choice could be risk-averse or risk-neutral. For this reason, we listed the respondents who answered the first question by checking do not know in a separate group.

Table 9 presents the number of respondents in each risk preference group, together with some descriptive characteristics of the forest and the harvest activity/plan. The result shows that the largest group of respondents (39.6 %) was risk-prone, i.e. they stated that they would rather take the risk by waiting for the market price instead of accepting the fixed price of 400 SEK/m$^3$. The smallest group of respondents (16.0 %) was risk-averse – they displayed an aversion to taking the risk. About one-forth of the respondents were indifferent between the two options. With respect to the average area of productive forest land and the average timber per unit area, the differences between these three groups are small. It means that, in the current context, the size of forest property and the growing stock of timber do not have any obvious impacts on the forest owner's attitudes toward risk. There are significant differences among the three groups in the share of owners who have conducted final felling during the past 6 years. The share of active owners within the risk-prone group is much higher than in the risk-neutral group, which in turn has a larger portion of active owners than the risk-averse group. The differences in the share of active owners suggest that a forest owner's attitudes toward risk had significant impacts on his/her final felling decision: the more a forest owner likes to take risks, the more likely that he/she conducts final felling. However, such a trend does not exist with respect the share of owners who planed to harvest in the coming 3 years.

*Table 9. Number of respondens, average size of forest, and the share of active owners in different risk-preference groups.*

| | Risk-averse | Risk-neutral | Risk-prone | Unsure | Whole sample |
|---|---|---|---|---|---|
| Number of respondents | 148 | 224 | 365 | 184 | 921 |
| Mean area of productive land (ha) | 151.7 | 151.1 | 166.7 | 102.4 | 149.5 |
| Mean growing stock of timber ($m^3$/ha) | 89.1 | 97.0 | 91.4 | 88.2 | 92.1 |
| Share of active owners (%) | 52.0 | 56.7 | 67.1* | 45.7* | 57.9 |
| Share of owners who plan to fell in coming 3 years (%) | 55.3 | 48.9 | 51.7 | 34.1* | 48.1 |

* Indicates statistical significance at the 5 % level of confidence.

About 20% of the respondents fall into the group of unsure owners. On average, a respondent in the unsure group had a smaller area of productive forest land than respondents in the other groups. Compared to owners in the other three groups, a lower share of the unsure owners had conducted final felling in the past 6 years, and an even lower share planned to harvest in the coming 3 years. A plausible interpretation of the result is the following: owners in the unsure group were less experienced in comparing different selling strategies because they had not conducted final felling in the past years, alternatively they were less motivated to make the comparison because they did not plan to harvest, than owners in the other groups. This could be one of the reasons why they stated that there did not know which option they preferred.

About one half of the respondents who answered question A answered also question B. The answers to question B are presented in Table 10. Theoretically, a respondent's answer to this question also reveals his/her attitudes toward risk. However, this question is more difficult to answer than question A, which is clearly indicated by the different numbers of respondents who answered these questions. The difficulty of question B implies that, in addition to a low response rate, the answers are more uncertain. Thus, this question is less suitable for the purpose of determining the attitudes to risk than question A. Our purpose of asking the respondents to answer question B is to examine the potential for the NIPF owners to make consistent choices involving uncertainty.

Given that the market price lies in the interval 360-440 SEK/$m^3$, it obviously does not make any sense for a NIPF owner to accept any price lower than 360 SEK/$m^3$, neither is it logical for a NIPF owner to reject a sure price of 440 SEK/$m^3$ and wait for the market price instead. A risk-averse owner, who stated that he/she would accept a sure price of 400 SEK/$m^3$ rather than waiting for an uncertain price in the interval 360-440 SEK/$m^3$, should be willing to accept a sure price within the interval 360-400 SEK/$m^3$. Similarly, for a risk-prone owner the lowest sure price which is more desirable than the uncertain market price must be greater than 400 SEK/$m^3$. The risk-neutral owners indicated that they were indifferent between accepting a sure price of 400 SEK/$m^3$ and waiting for an uncertain price in the interval 360-440 SEK/$m^3$. Clearly, a sure price which is lower than 400 SEK/$m^3$ could not be preferable to the uncertain market price for a risk-neutral owner. For risk-neutral owners, the lowest sure price that is preferable to the uncertain market price should be higher than 400 SEK/$m^3$. For an owner who did not know his/her preferences between a sure price of 400 SEK/$m^3$ and the uncertain market price, the lowest sure price that is preferable to the uncertain market price could be anywhere between 360 and 440 SEK/$m^3$.

Based on the above arguments and the result presented in Table 10, we can tell that 40 % of the answers to question B were (likely) consistent with the attitudes toward risk revealed in the answers to question A. About one forth of the answers is obviously inconsistent with the attitudes toward risk. And nearly one third of the respondents did not give a sensible answer: some of these respondents stated that they would accept a sure price lower than 360 SEK/$m^3$ instead waiting for the market price that is at least 360 SEK/$m^3$; others stated that a sure price could be the preferred choice only if it was greater than 440 SEK/$m^3$.

*Table 10. Distribution of respondents over the lowest preferable sure price for different risk-preference groups.*

| Lowest preferable sure price (SEK/m$^3$) | Risk-averse | Risk-neutral | Risk-prone | Unsure | Sum |
|---|---|---|---|---|---|
| 0 – 359 | 14 | 4 | 5 | 2 | 25 |
| 360- 399 | 13[a] | 2 | 4 | 1[b] | 20 |
| 400 | 69 | 29 | 35 | 6[b] | 139 |
| 401-440 | 3 | 70[b] | 113[a] | 8[b] | 194 |
| >440 | 2 | 39 | 97 | 4 | 142 |
| Sum | 101 | 144 | 254 | 21 | 520 |

[a] Consistent with the answer to question A.

[b] Probably consistent with the answer to question A.

As pointed out earlier, question B is much more difficult to answer than question A. That a respondent did not give a reasonable answer to question B does not mean that he/she did not know the true answer to question A. However, an inconsistency between the answers to the two questions is a strong indication that the respondent was uncertain about the answers to both questions, or he/she answered the questions in an arbitrary manner. In either case, it is likely that the respondent failed to identify the truly preferred choice between the fixed price of 400 SEK/m$^3$ and the uncertain market price.

## 3.6. Perceptions of return and risk

With a mature forest stand (a stand in the final harvest stage), a forest owner can harvest the stand and invest part of the revenues somewhere outside forestry. He/she can also wait with harvesting the stand and keep the capital in the forest. Which option the forest owner chooses depends on, among other things, his/her perception of the returns and risks of the alternative investments. In this study we considered three investment alternatives outside forestry. These are the forest account[16], an ordinary

[16] The forest account is a special bank account which enables a NIPF owner to spread parts of his or her timber income from a particular year over the coming ten years, and thereby reduce his or her tax burden.

bank account, and a portfolio of stocks and bonds. For each alternative, the respondents were first asked to determine whether it gave a lower, equal or higher return as compared to the mature forest stand. Then they were asked to determine whether the risk of the investment was lower, equal or higher than the risk of the keeping capital in the mature stand. The active and inactive respondents' judgements of the return and risk are summarized in Table 11 and Table 12, respectively. The results show that the respondents hade widely different perceptions of the relative returns and risks of each investment alternative.

*Table 11. Judgements of the return of three alternative investments relative to the mature forest. Share of active owners* (AO) *and inactive owners* (IAO) *with different judgements.*

| | Bank account | | Forest account | | Stocks/bonds | |
|---|---|---|---|---|---|---|
| | AO | IAO | AO | IAO | AO | IAO |
| Lower return | 72.0 | 76.7 | 58 | 62.8 | 28 | 27 |
| Equal return | 23.4* | 17.2* | 33.5 | 28.7 | 21.2 | 25.7 |
| Higher return | 4.7 | 6.1 | 8.5 | 8.6 | 50.9 | 47.4 |

* Indicates statistical significance at the 5 % level of confidence.

A majority of the owners (over 70 %) displayed a belief that the ordinary bank account gave a lower return than the mature forest. About 20 % of the respondents believed that the return from the bank account was equal to the return from the mature forest. And about 5 % of the respondents stated that the return from the bank account was higher than the return from the mature forest. Compared to the ordinary bank account, a smaller share of the respondents believed that the forest account gave a lower return than the mature forest, and a larger share of the respondents believed that the return from the forest account is equal to or higher than the return from the mature forest. The result indicates that most of the respondents were aware of the fact that the forest account normally gives a rate of return than an ordinary bank account. Even so, a majority of the respondents believed that the mature forest outperformed the forest account in terms of the expected return.

About 50 % of the respondents believed that stock/bonds would give a higher return than the mature forest. Almost 30 % of the respondents stated that stocks and bonds gave lower return than the mature forests. The result is somewhat surprising, since the timber growth rate in mature forests is generally very low. A possible explanation is that the respondents in general had very optimistic expectations about the development of timber prices in the foreseeable future. "Skogsbarometern 2006" (Gällstedt et. al., 2006) reported that there was a very optimistic view among NIPF owners about the timber prices during the next three years.

NIPF owners had widely different opinions about the risks of different investment alternatives. A majority of the respondents believed that the bank account as well as the forest account had a lower risk than the mature forest. However, a much larger share of the respondents believed that the bank account had a higher risk than the mature forest, as compared to the share of respondents who believed that the risk of investment in the forest account is higher than the mature forest. This difference is difficult to explain. Table 12 shows that about 85 % of the respondents believed that investment in stocks or bonds was more risky than keeping the capital in the mature forest. At the same time about 4 % of the respondents believed that the risk involved in stocks and bonds was lower than in the mature forest.

*Table 12. Judgements of the risk of three alternative investments relative to the mature forest. Share of active owners* (AO) *and inactive owners* (IAO) *with different judgments.*

| | Bank account | | Forest account | | Stocks/bonds | |
|---|---|---|---|---|---|---|
| | AO | IAO | AO | IAO | AO | IAO |
| Lower risk | 40.2 | 38.4 | 59.3 | 54.1 | 4.1 | 3.7 |
| Equal risk | 41.0 | 39.4 | 30.7 | 33.6 | 9.5 | 11.8 |
| Higher risk | 18.8 | 22.2 | 10.0 | 12.3 | 86.4 | 84.4 |

In the survey we did not specify what the mature forest looked like. Even if we did, the respondents may still have quite different opinions about the return and risk of the mature forest, due to different perceptions of the biological and economic factors that affect the return and risk of the mature forest. The differences in the judgments of the return and risk of the mature forest among the respondents would have contributed to the different beliefs about the relative return and risk of the alternative investments. However, the widely different perceptions of the return and risk of each investment alternative indicate that NIPF owners make different judgements about the return and risk of investment outside forestry.

### 3.7 Impacts on harvest intensity

In order to examine the impacts of uncertainty on the final felling decision, we identified the preferred investment alternative for each respondent based on his/her attitudes toward risk and on his/her judgement of the relative return and risk of different alternatives. For example, if a respondent displayed an aversion to taking risks, and at the same time believed that the bank account gave a higher or equal return but a lower risk than the mature forest, then the bank account is preferred to the mature forest. Since we are interested in examining the impact of uncertainty on the final harvest decision, what is important is whether a NIPF owner prefers to keep the capital in the forest or to harvest the forest and invest in some of the alternatives. If a NIPF owner prefers one of the three alternatives to the mature forest, then we say that the preferred investment is outside forestry. If none of the three alternatives outside forestry is preferred to the mature forest, then his/her preferred investment alternative is the mature forest. A third possibility is that, based on a forest owner's attitudes toward risk and his/her perceptions of returns and risks, we can not determine if (some of) the alternatives outside forestry is preferred to the mature forest. In that case, we say that the preferred alternative is indecisive.

According to the preferred investment alternative we grouped the respondents into three groups. Figure 2 presents the growing stock of timber per ha of productive forest land for NIPF owners with different preferred investment alternatives. Intuitively, forest owners who prefer the mature forest to the investment alternatives outside forestry are less likely to conduct final felling than those whose preferred investment alternative is indecisive. And forest owners with indecisive investment alternative are less likely to conduct final felling than owners who prefer one of the investment alternatives outside forestry to the mature forest. Thus, we would expect forest owners whose preferred investment is the mature forest to have a larger growing stock of timber per ha than those whose preferred investment is indecisive, and the latter group of owners to have a larger growing stock of timber per ha than those who prefer an investment outside forestry. The result presented in Figure 2 displays a very weak, statistically insignificant, correlation between the average growing stock of timber per ha and the preferred investment alternative.

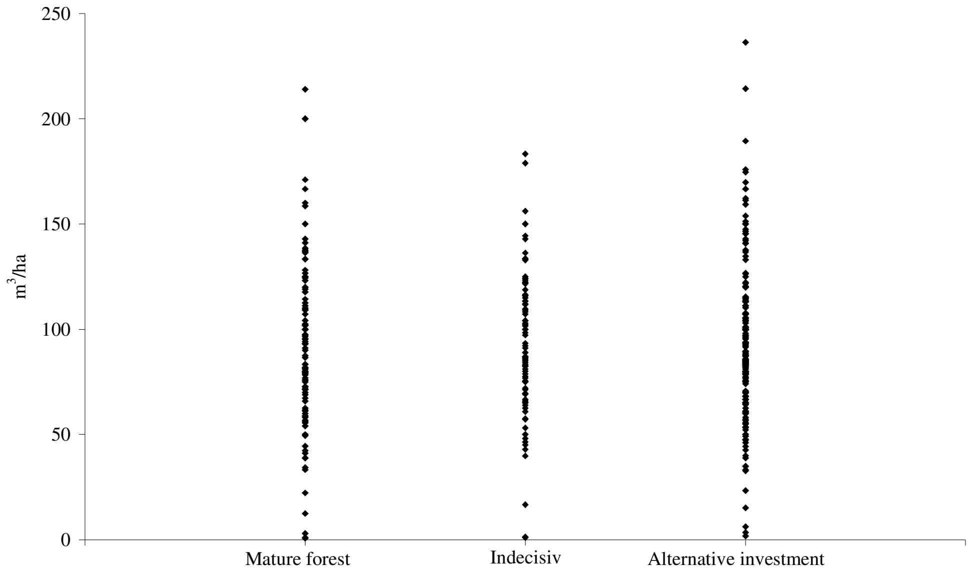


*Figure 2. The growing stock of timber (m$^3$/ha) on productive forest land. Respondents are grouped according to their preferred investment.*

Figure 2 shows that there are great variations in the growing stock of timber per ha among the respondents within each group. It means that there are other factors (in addition to the harvest intensity) that affect the growing stock of timber. Therefore, even if the preferred investment alternative has significant impacts on the harvest intensity, it may happen that such effects can not be identified by examining the growing stock of timber.

Table 13 shows the share of owners with different preferred investment alternatives and also the area of productive land, the growing stock of timber, and the share of owners who conducted/planned to conduct felling activities for each owner group. For the active owners, we calculated the volume felled per hectare of productive forest land (i.e. the total volume a forest owner felled during the past 6 years divided by the area of his/her productive land and divided by 6 to get the annual volume) as a measure of the harvest intensity. ANOVA shows that there are no significant differences between the owner groups with respect to the mean areas of productive land and the mean growing stocks of timber per hectare. The share of active owners among those who preferred the mature forest to the other investment alternatives is lower than in the other groups. The average harvest volume per ha productive land is also lower for the active owners whose preferred investment alternative is the mature forest than owners with other preferences over the investment alternatives. The result suggests that on average NIPF owners who prefer the mature forest to other investment alternatives harvest less intensively than owners in the other groups.

*Table 13. Owners with different preferred investments, area of productive forest land, growing stock of timber, and felling activities.*

| | Mature forest | Indecisive | Alternative investment | All with preferred investment |
|---|---|---|---|---|
| Share of respondents (%) | 26.3 | 25.6 | 48.1 | |
| Area of productive land (ha) | 127.4 | 169.2 | 172.4 | 149.6 |
| Growing stock of timber ($m^3$/ha) | 92.0 | 91.8 | 92.4 | 92.1 |
| Share of active owners (%) | 54.3 | 64.6 | 62.8 | 57.9 |
| Annual volume felled per ha of productive land (Standard deviation in parenthesis) | 2.60 (5.44) | 2.77 (6.05) | 2.73 (4.51) | 2.71 (5.12) |
| Share of owners who plan to fell in coming period (%) | 49.7 | 50.9 | 53.2 | 48.1 |

The felling per hectare of productive forest land of each respondent for the whole period 2001-2006 is plotted in figure 3 below. The figure shows, although weakly, a positive correlation between increased felling per hectare and preference for some of the alternative investments. There is also a positive relationship between preference for the alternative investments and having been active in final fellings in the period surveyed.

In table 14, active and inactive owners are shown after risk-preference and preferred investment. In the risk-averse group, the share that has preference for some of the alternative investments is significantly lower than the share among all respondents that have a preferred investment. Even though not statistically significant from the overall mean, the risk-averse group has the highest share of owners with preference for the mature forest. The table also shows that the risk-prone group has the highest share of owner with preference for some of the alternative investments.

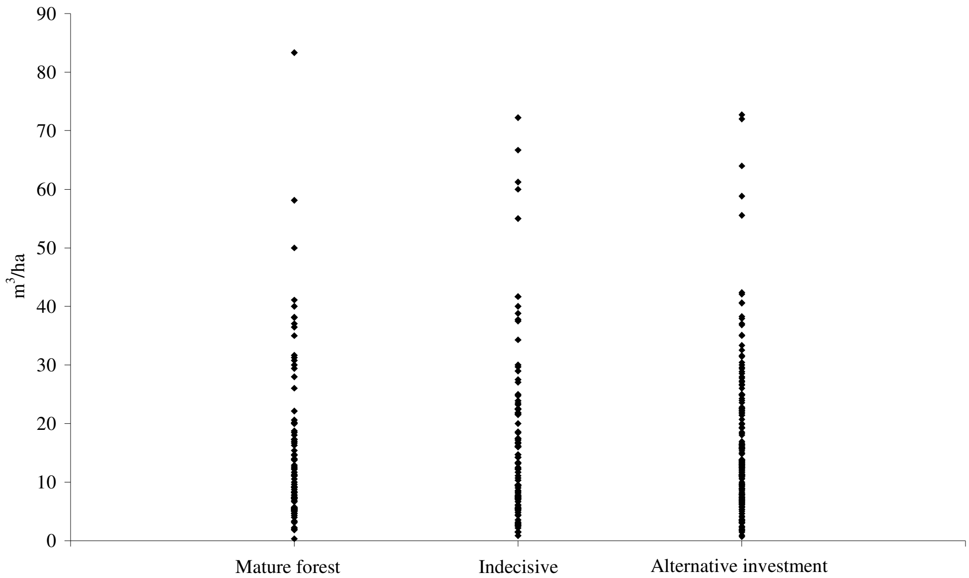


*Figure 3. Fellings per hectare of productive forest land. Respondents are grouped after their preferred investment.*

*Table 14. The shares (%) of owners in each of the risk preference groups having been active and inactive, reported after preferred investment. Risk-averse owners are 130, risk-neutral owners are 215, and risk-prone owners are 335 respondents in total.*

| Risk preference | Preferred investment | Active | Inactive | Total |
|---|---|---|---|---|
| Risk-averse | Mature forest | 14.6 * | 17.7 * | 32.3 |
| | Indecisive | 27.7 | 19.2 | 46.9* |
| | Alternative investment | 12.2 | 9.1 | 20.7* |
| Risk-neutral | Mature forest | 8.4* | 14.9 * | 23.3 |
| | Indecisive | 16.7 | 9.3 | 26.0 |
| | Alternative investment | 31.6 | 19.1 | 50.7 |
| Risk-prone | Mature forest | 17.6 | 7.8 | 25.4 |
| | Indecisive | 12.2 | 5.1 | 17.3* |
| | Alternative investment | 36.4 | 20.9 | 57.3* |
| All with preferred investment | Mature forest | 15.9 | 10.1 | 26.0 |
| | Indecisive | 16.0 | 9.7 | 25.7 |
| | Alternative investment | 29.4 | 18.8 | 48.2 |

* Indicates statistical significance at the 5 % level of confidence.

## 4. Summary and Discussion

In this paper we report a study on NIPF owners' risk preferences and their assessments of the return and the risk of alternative investments relative to keeping mature forests standing. We also study the relationship between the risk preferences, the assessments of the return and risk, and the felling activities conducted by the NIPF owners. Our starting point is that the subjective judgements made by NIPF owners about the return and risk of different investment alternatives, together with their risk preferences influence their decisions. Our aim is to acquire a better understanding of the reasons why NIPF owner characteristics affect their behaviour.

The assessments of the return and risk in the mature forest relative to alternative investments vary widely among the respondents. The results show that a majority of both active and inactive owners assessed that a mature forest stand gave a higher return than a forest account or an ordinary bank account, and a rather large share of the owners believed that a mature forest gave a higher return than the stocks and bonds as well. One factor that may have affected the respondents to appreciate the return from the mature forest is a strong belief in rising timber prices in the next few years. In our survey, we do not give the respondents any definition of the term risk since we are more interested in the effects of what he or she perceives as the risk. The results from the assessments of risk show that a majority of both the active group and the inactive group associates the forest account with lower risk and a vast majority associate stocks and bonds with higher risk compared to mature forest.

Our study showed that almost half of the NIPF owners were risk-prone, which might seem to be a rather large share. Only a unit price was mentioned in the survey and if the respondent regarded this as the total amount at stake it is possible that he or she took a more gambling attitude. However, a large share of NIPF owners being risk-prone was also found by Lönnstedt & Svensson (2000) who in addition found that NIPF owners showed decreasing absolute and relative risk aversion. Our result showed that the NIPF owners risk preference had significant impacts on the decision to fell timber. The owners who were risk-prone were significantly more active in final fellings than the other groups.

When sorting the respondents into groups after their preferred investment, it was found that the largest group was the one with preference for one of the alternative investments. This group and the group with indecisive preference had higher shares of active owners than the group of owners with preference for the mature forest. The result indicates that preference for mature forest as investment increases the length of the intervals between fellings and also makes the owner fell less on each occasion. It was further found that risk-averse owners tend to prefer keeping capital in the mature forest to a larger extent than the other risk preference groups, while risk-neutral and risk-prone tend to move capital to some alternative investment to a larger extent. This tendency is particularly strong for the risk-prone owners.

When it comes to the consistency between preferences and management behaviour, the results show that the management differs between groups of owners with different preferences. If we for simplicity assume that there are only two types of risk-preference among NIPF owners, risk-averse and risk-prone, we can say that consistency between preferences and management can be fulfilled both in the case when management activities are the same in both groups, and when they differ. If both groups prefer to keep mature forests, their behaviours are consistent with their preferences if the risk-averse group judges the forest as less risky and the risk-prone group judges the forest more risky, than the alternative investments. If the two groups, however, makes the same judgements about the risks, their management behaviour must differ in order to achieve consistency between preferences and judgements. The result of our study implies the latter situation, where the groups show differences in the management behaviour. It should be pointed out that the result is not a sufficient condition for consistency, there is still the possibility that neither group is managing their forests consistently with their preferences.

Awareness of the many different assessments and preferences might give the NIPF owner reason to reassess his or her assessment. Many forest owners would benefit by more actively thinking of their forests in terms of investments and evaluate whether this investment, or some other investment, is the type that best corresponds to their preferences. In the valuation of how consistent the forest investment is to the preferences of the NIPF owner, clearly other properties than the risk and return, such as all the non-timber benefits, must also be included. This clearly complicates the process, but the process would benefit from more objective information about the risks involved with forest investments. Here is also need for policy makers to consider how to provide as objective information as possible to the NIPF owners.

A NIPF owner should be aware of the objectives and reasons underlying their forest management. Ideally, the NIPF owner should consider what benefits and risks he or she wants. But it might be that he or she listens to advice of others, or tries to achieve a management that he or she has perceived as the most socially acceptable. NIPF owners who to a large degree base their management decisions on advice from others must make sure that their own preferences are consistent with the management proposed by their advisors. If not, they should not listen to the advices given to them. With awareness of the variety in judgements and preferences, the NIPF owner could more independently decide the best management for him or herself. NIPF owners should also ideally be willing to continuously re-evaluate the risk and return of their forest stands. The risk and return of the forest stand is not constant over time.

As mentioned, the results imply a need for policy-makers to provide information to NIPF owners concerning the risk and return in the forest investment in order to aid them in making their optimal allocations. Policy-makers should also be aware of the heterogeneity in both the assessments of risk and return and the risk-preferences. If the policy maker has the objective in influencing the management behaviour of NIPF owners, the policy maker must be aware of that the use of any single policy instrument may have different effects on different types of owners. Considering that NIPF owners have different preferred investments, policy makers might need to provide more information about the management alternatives to the NIPF owners. Also, the policy makers would need more information on how owners can be expected to react to different policy implementations.

Our result shows that whenever possible, research on NIPF owners should be conducted in a way allowing other preferences than risk-neutrality. The risk-preferences' effect on the decision to fell implied that more research is needed on the mechanisms underlying the risk-preferences. Many studies have found significant correlations between owner characteristics and management behaviour. We believe that further studies on risk-preferences will give insights to how owner characteristics might form risk-preferences, which in turn affect the decision to conduct final felling. Also, more research could reveal how risk-preferences affect other management activities than final fellings. To continue that investigation on the consistency between preferences and behaviour we believe that studying how revenues from NIPF fellings are invested is one possible way.

It should be emphasised that we do not regard the different objectives, judgments and preferences among NIPF owners per se as problematic. Rather that the variety of attitudes and perceptions might not be sufficiently reflected in their management behaviour. That every NIPF owner manages his or her forest in accordance with their objectives and preferences is a necessary condition for achieving a socially optimal forest management.

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# Review of benefit transfer studies in the forest context

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**1. Abstract**
Non-timber benefits (NTBs) are increasingly being compared with timber values in the crafting of multifunctional forest policies. Since most NTBs are non-marketable goods, special valuation methods are developed for their evaluation. Due to cost and time requirements, it is neither feasible nor desirable to conduct primary valuation studies in each policy relevant case. As an alternative, the benefit transfer (BT) approach is used to transfer benefits estimated by previous studies in a similar context to the policy context of interest. We take stock of the growing literature applying BT techniques for NTBs, to answer two main questions: How have BT methods been used to date in the forest context? What are the main lessons from NTBs transfers? We found 12 studies dealing with BT between forest sites and a few others in which forest sites were among other analyzed environmental resources. The majority of them transferred recreation benefits using the BT function based either on contingent valuation or travel costs estimations. They mainly focused on four areas: physical attributes of forests, time aspects, methodological improvements to increase the estimated accuracy and reduce surveys costs. Our results get closer to answering the question of "how and under what circumstances can NTBs be reliably transferred?"

**Key words:** non-timber benefits, benefit transfer, forest

## 2. introduction

An important part of the environmental economics profession is to value environmental goods in monetary terms, i.e. estimate how much people are willing to give up of other goods and services they consume in exchange for a better natural environment. The rationale is to make the benefits of a better environment transparent and comparable with other costs and benefits in private and public decision-making that typically have market values, such as timber, working hours, harvesting machines etc. In forest management, values of so called non-timber benefits (NTBs) have increasingly been recognized as an important decision-making support in developing multi-functional forest policies that gradually shift the emphasis from traditional timber values to a broader spectrum of societal benefits from forests (Cubbage et al. 2007). The use of such values in policy-making is already common in the USA (e.g. by the US Forest Service), and is becoming so in Europe. Increased use is fed by demand from public agencies as well as growing academic interest. However, conducting new, expensive and time consuming primary studies to value NTBs in each policy relevant case may not be feasible or even desirable. Therefore, many practical applications by different public agencies and consultancies use information about values from existing studies and transfer to unstudied, similar sites of policy interest. This is called “benefit transfer” (BT), or more generally “value transfer”. A parallel literature in environmental economics has developed to investigate the validity and reliability of different BT methods, starting from the early 1990s. Common areas where BT is used and studied are for health benefits (e.g. value of statistical life), water quality and recreation benefits. The use of BT methods in the forest context originated more recently, but has also been seen as a potentially useful tool for decision-making. The topic is also of growing academic interest, as it is sometimes questioned whether BT can be reliable for more complex and site-specific goods, such as forests. The aim of this paper is to take stock of the BT literature in the forest context, and to investigate two main research questions: (1) How have BT methods been used to date for non-timber benefits?; and (2) What are main challenges and lessons learned from transferring non-timber benefits to date? To answer these two questions we first give a brief overview in the next section of classifications of forest functions and economic values, and types of primary valuation methods. In section four, we explain the types of BT methods in use, while we review the BT literature in section five. Section six attempts to distill some of the main experiences and challenges in using BT in the forest context. The conclusion suggests key areas of future research and gives an assessment of the circumstances (if any) under which NTBs can be reliably transferred.

# 3. Forest functions and values

Forest ecosystems generate a wide range of goods and services, in addition to timber. Broadly defined, these forest functions are the benefits people obtain from forests (Barbier and Heal, 2006, Pearce, 2001). Many classifications of them have been used at times at different geographical levels: regional, national and international.[17] We follow the division suggested by Navrud and Brouwer (2007) and distinguish, apart from timber production, four other main forest functions: recreation, non-timber commercial products, ecosystem services, and non-use values of forests (Figure 1.). We call them non-timber benefits (NTB).

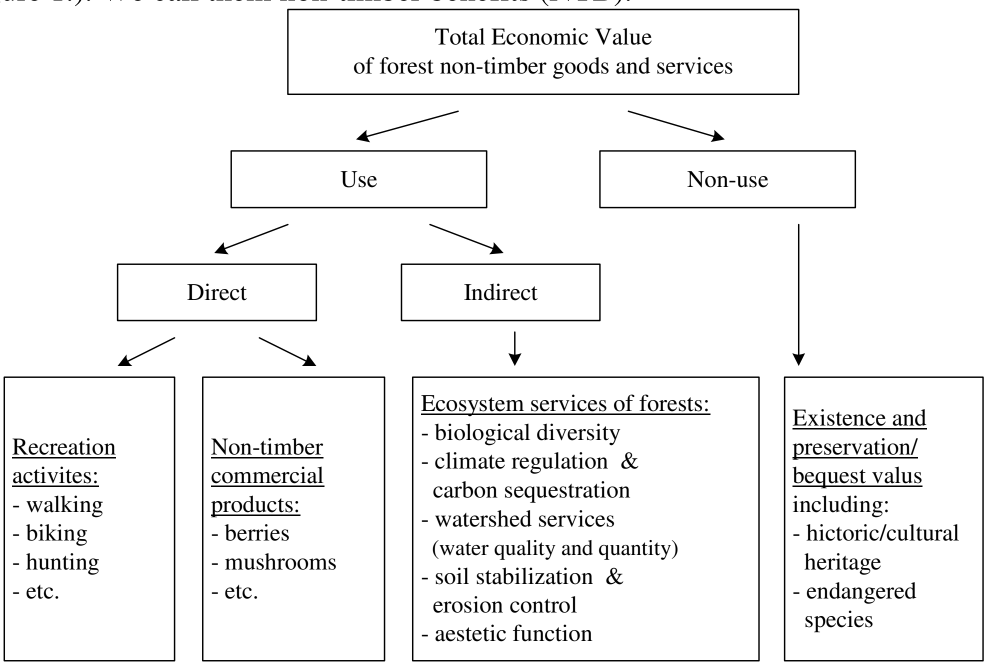


Figure 1. Total economic value of forest non-timber goods and services.
Source: Adapted from: Navrud and Brouwer, 2007.

There could be different interactions between particular forest functions such as complementarity (for example it could be a case between aesthetic function and recreation) or excludability (forest production vs. ecological diversity). In the case of complementarity, it is a difficult task to analyze functions separately and sometimes a more general approach is needed. Some of the functions are hard to define in a unique and general way, since usually it varies depending on sites.

[17] For example: Costanza et al. (1997) and De Groot et al. (2002) propose a classification of ecosystem functions, and summarize ecosystem services into no less than 23 major categories that are all relevant to forest ecosystems.

With forest functions, different economic values could be related. It depends on the way individuals may benefit from them. The main distinction is between "use" and "non-use" (passive use) values. Use values relate to actual, planned or possible use. These use values put together direct and indirect forest values, indirect values being more associated to forest services, like ecosystem services. An example of actual use is a visit to a forest site for recreation. The non-use value refers to the willingness to pay to maintain some good in existence even though there is no actual, planned or possible use (Bateman et al., 2002). This subset can be divided into existence, altruistic and bequest values. Existence value expresses the case where the value has no use to anybody. Altruistic and bequest values arise when the individual is concerned about preserving this good for others (not for her/himself). In the case of forests the example illustrating the non-use value could be the preservation of endangered species.

While several goods such as timber have market prices, or are at least partially traded in markets (such as berries or mushrooms), for most of the forest services mentioned in Figure 1 such markets do not exist. The latter group we call non-market goods and services (NMG&S). Since prices cannot reflect the benefits they provide to society, there are other methods to estimate their values.

Capturing these values is possible using economic valuation methods. Two main groups of valuation techniques have been used in the forest context. The first includes methods based on revealed preferences (RP) such as the travel cost method (TCM) and the hedonic price method (HPM). The second group is based on stated preferences (SP), and includes the contingent valuation method (CVM) and Choice Modeling (CM).

RP methods derive a measure of consumer surplus (CS) based on existing markets and demand curves of some private goods. When expenditures on a private good vary with levels of environmental amenities, under certain conditions a value of the environmental amenity can be derived (Young, 2004). SP methods use constructed/hypothetical markets. Based on specially prepared questionnaires, it is possible to obtain in a direct way the respondents' willingness to pay (WTP) for non-market goods and services. Shrestha and Loomis (2002) state that because SP and RP estimations are derived from differently constructed demand functions (CVM is based on the Hicksian demand function, whereas TCM is based on the Marshallian function), SP measures would be larger than RP even when there is no measurement error.

Whereas the application of RP methods is restricted to particular forest functions connected with use values (TCM for recreation, HPM for e.g. aesthetic functions), the SP methods have no such limitations. SP methods can estimate both use and non-use values related to a variety of functions. What is in general valued by those methods are environmental changes (in quality or quantity) but not total economics values.[18]

Studies that are designed and carried out for selected forest sites which use either RP or SP methods we call primary studies. Many primary studies exist on recreation, biodiversity, watershed benefits or climate benefits. There are several literature reviews on the use of environmental valuation in forestry (Bishop, 1999, Holmes and Boyle, 2003, Pearce, 2001a, b). However, the majority of valuation studies concentrate on just one forest function – forest recreation. Much of the literature is recorded in environmental databases such as EVRI (Environmental Valuation Reference Inventory), ENVALUE, RED and Ecosystem Services Database. There are also a few which deal only with forest NMG&S, mostly on the national level (France, Germany, Austria, Switzerland and Italy). The majority of studies have been carried out in Western Europe and North America, though primary research in developing countries is growing fast. Given the large and growing body of valuation research, a separate discipline has developed within environmental economics using existing information in new contexts – or so-called benefit transfer (BT), which we turn to next.

## 4. Benefit transfer in the forest context

Benefit transfer (BT) uses existing values as an approximation for a new study. The specific site from which information or data are derived is typically called the "study" site, while the site to which they are transferred is called the "policy" site.[19] The two main advantages of performing BT instead of conducting new valuation studies are the lower cost and the shorter estimation time. This is why BT techniques are of great interest to practitioners and have contributed to rapid growth of BT applications over the last two decades. However, the use of BT introduces additional uncertainty about welfare estimations to the level already present in primary valuation results. Because of this, BT is regarded as a "second-best" strategy, compared to primary valuation surveys conducted to address valuation needs for specific resources and policies in terms of space, specific target population and time.

[18] In the past there were attempts to value total economic values of environmental services (for example Costanza et al. 1997), but this approach has been criticized and is not useful for Cost-Benefit Analysis which is typically related to environmental changes from proposed policies. One of the main points of critics is that to value (marginal) changes it is possible to assume that supply and prices of other goods are constant. For large changes and totals, such assumptions generally do not hold. However in some forest planning calculations, the total economic value of sites is present, for example in cases of afforestation projects or clearing of whole sites to give space for investment.

[19] There are also possibilities to transfer values regarding a particular policy (for example – national preservation policy of X% of forests) that may or may not be related to specific sites. We use the terms "study" and "policy" sites for the sake of simplicity.

In an economic theory framework, for the two populations of the study and policy sites to have the same utility derived from increased provision of an environmental good, it requires the same form of utility functions,[20] prices (of market goods), income levels, and vectors describing both the change in environmental qualities/quantities and the environmental situation before and after the change. In the indirect utility function, individual's A and B willingness to pay (WTP) for a change in forest quality/quantity can be presented in equations (1) and (2), which are equal if equation (3) is true:[21]

(1) $V^A(p, I, Q_o) = V^A(p, I - WTP, Q_1)$
(2) $V^B(p, I, Q_o) = V^B(p, I - WTP, Q_1)$
(3) $V^A(p, I - WTP, Q_1) = V^B(p, I - WTP, Q_1)$

where: p – vector of prices of goods and services, I – the individual's income, Q – vector describing forest quality/quantity, indices: 0, 1 – before and after changes, respectively.

For forests the Q in the indirect utility function is quite difficult to specify, but several dimensions of forest characteristics may be important (see Figure 2.). Which forest attributes influence individuals' utility function, and their WTP or CS, are not fully understood. Matthews et al. (2007) claim that, for example, in the forest recreation context, WTP may plausibly be related to measurements of site quality, forest size and other attributes, such as the percentage of woodland area covered by broadleaf trees; but in fact, there have not been many data collection exercises that allow the pooling of data across a sufficiently large number of sites to safely establish such a relationship.

Depending on the exact aim and the utilization of a BT application we can deal with an evaluation of the change in quality or quantity of: (a) a particular forest service/good, (b) a particular value, e.g. a non-use value or (c) a set of functions and values, when a complex policy scenario is presented. The latter case could be depicted by a scenario describing an increase in the natural protection system, where respondents can value either biological diversity or improvement in recreation due to more interesting surroundings or endangered species or other factors.

Economic theory has developed a number of BT approaches that try to adjust values for the differences that typically exist in practice between study and policy sites. Therefore, in some of these approaches the requirement of similarities can be relaxed if we have sufficient data from

[20] Which are typically assumed to be constant over time (or to vary with time in the same way) for both. In practice, individuals' preferences are typically not stable over longer periods (depending for example on cultural changes or technological developments).
[21] This follows the standard neoclassical environmental economics approach.

several sites or studies allowing us to adjust for existing differences between "study" and "policy" sites.

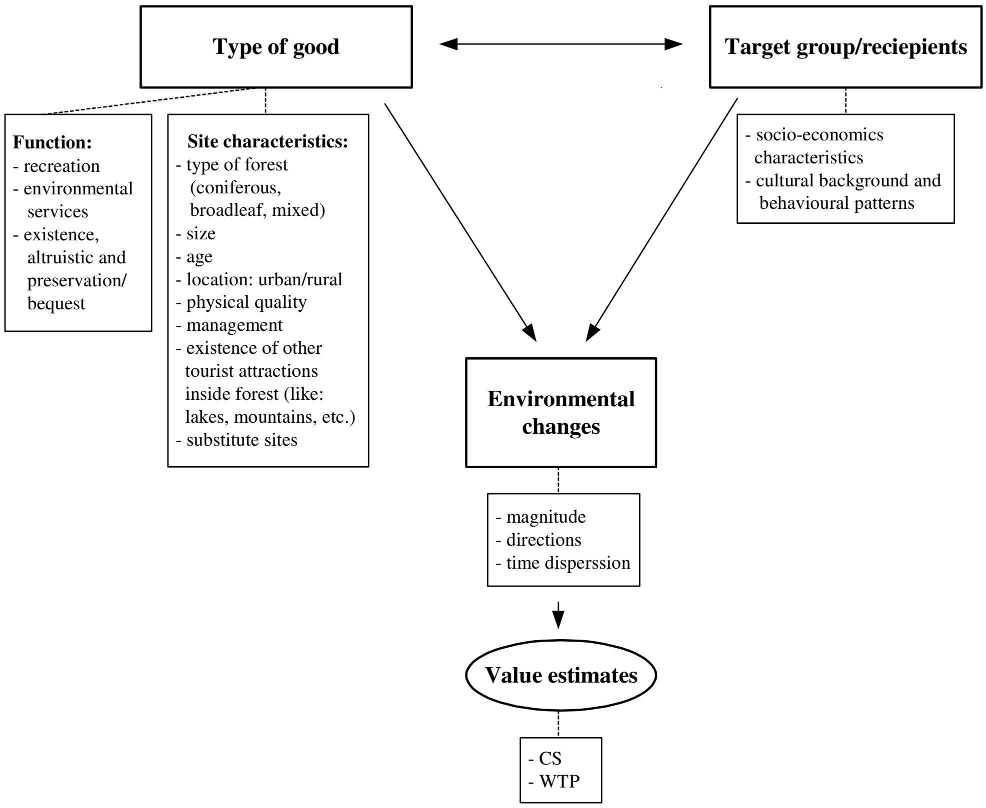


Figure 2. Valuation elements in the forest context.

BT approaches can be divided into two main groups: unit value transfer (UVT) and benefit function transfer (BFT). Unit value transfers can be divided into: naïve (unadjusted) and adjusted benefit transfers (see Table 1). The naïve unit transfer is simply a single point estimate transfer which could be based on one or more valuation surveys (in the former case we can pick a study of the most similar site following "expert judgment"). The term "adjusted" is usually used to describe income adjustment. When transferring a point estimate from study site to policy site, it is assumed or implied that the two sites are identical across the various factors that determine the level of benefits derived from environmental goods or services. With a range of values from several studies the central tendency (mean, median) is typically transferred to the policy site. In the case of an average value transfer, it is assumed that the benefits of the policy site are around the mid-level of benefits measured for the study sites incorporated into the average value calculation (Rosenberg and Loomis, 2001). Yet there is an assumption that, apart from the income level, the analyzed populations do not vary in terms of other characteristics. In forest BT literature, however, there are attempts to apply another means of adjustment - site-adjustment (i.e. adjusting for the differences in forest attributes between sites (Matthews et al. 2007, Scarpa et al. in Navrud and Ready, 2007).

Table 1. Unit value transfer approaches.

| Unit value transfer | |
|---|---|
| Naïve<br>$WTP_p = WTP_s$ | Income adjusted<br>$WTP_s = WTP_s \, (Y_p/Y_s)^{\square}$ |

Where: WTP – willingness to pay, s – the study site, p – the policy site, Y – income level and □ - income elasticity of demand for the non-market commodity evaluated.

A more technically advanced approach instead of transferring just unit values is to transfer entire functions allowing the use of more of the information at the policy site (i.e. in addition to income at the policy site, other socio-economic characteristics describing population may also be plugged into the function). In this case we can distinguish three subcategories. The first category is the benefit or demand[22] function transfer from a single site (for an example of BTF based on SP see Table 2.). In this case, unlike UVT, more information is taken into account in the transfer. The first step in an implementation of the BFT approach is to find a study which reports the regression function for a welfare estimate (information about parameters). To calculate benefits at the policy site, the information about parameters from the "study" site should be combined with data from the "policy" site such as a set of environmental characteristic of the place including information of substitutes and population characteristics. In the case of the demand function transfer, not welfare estimates, but number of visits to the site from TCM models are transferred, and based on that, CS is calculated. The main problem with this method arises from using estimates just from a single site, as this leads to omissions of some possibly important variables due to the lack of variation.

The second method – a meta analysis (MA) function – is based on several studies, where the result from each study (i.e. mean WTP) is treated as a single observation in a regression analysis. This allows an estimate of the statistical relationships between values reported in primary studies to explanatory variables capturing heterogeneity within and across studies (e.g. differences in value construct measure, populations and methodology within and across studies) (Bergstrom and Taylor, 2006). In general the MA

[22] In some cases, when the TC method is used in the primary study.

regression differs from a BFT by one explanatory variable – characteristics of the study (i.e. primary surveys methodology – see Table 2.)

Both those techniques, but especially MA, allow the similarity requirements between sites, goods, studies and populations to be relaxed and they enable a test of the methodological choices of primary studies if the heterogeneity is appropriately captured in the models. The main advantage of transferring whole functions to a policy site or building a regression based on estimates from many primary surveys (MA) is the increased precision of tailoring a benefit measure to fit the characteristics of the policy site. MA has been concerned with understanding the influence of methodological and study-specific factors on research outcomes (Rosenberger and Loomis, 2002). This is why the MA-BT approach could be used to evaluate some environmental functions – e.g. outdoor recreation – based on different environmental resources which provide this service (forests, lakes, beaches etc.). Because of the possibility of the inclusion of multiple population and site characteristics, MA can adjust for differences – but such variables should be available in the first place.

Table 2. Function transfer approaches.

| Value functions | |
|---|---|
| Based on a single survey (Benefit function transfer) | Based on multiple surveys (Meta-analysis) |
| $WTP_i = a + bX_{ij} + cY_{ik} + dS_{il} + e_i$ | $WTP_r = a + bX_{rj} + cY_{rk} + dS_{rl} + fZ_{rm} + u_r$ |

Where: $WTP_i$ – willingness to pay of a respondent (i), $X_{ij}$ – site and good characteristics (j), $Y_{ik}$ – respondent characteristics (k), $S_{il}$ – substitute site characteristic (l), e – random error, $WTP_r$ – mean willingness to pay for a study (r), $Z_{rm}$ – study characteristics (m), u – random error and a, b ,c , d are parameters.

Apart from these two groups of functional BT techniques, we can also distinguish the structural benefit transfer based on calibration of preferences. This approach requires selection of a preference specification capable of describing individual choices over a set of market and associated non-market goods to maximize utility when fencing budget constraints. Then the analytical expressions for tradeoffs being represented by the set of available benefit measures are established. The next step is to use the algebraic relationships with the estimates from the literature to calibrate the parameters of the model. These models offer the basis for new tradeoffs, i.e. for developing “transferable” benefit measures (Smith et al., 2006). A method belonging to this group is the Bayesian Approach (BA) which has been implemented recently to transfer environmental values (Leon-Gonzales and Scarpa, 2007; Leon et al. 2003, Leon et al. 2002). BA is based on the

Bayes theorem that involves the combination of prior information with sample information in order to derive a posterior distribution from which an inference can then be made. It assumes that there are some data or known quantities from earlier valuation surveys and prior beliefs (e.g. expert opinions) about unknown parameters (e.g. mean CS). BT estimates in this case can be obtained by assuming a joint probability function that describes how the unknown quantities and data behave in conjunction. This method makes it possible to reduce sample size or to choose the proper set of sites (i.e. in terms of forest characteristics) from which information is transferred.

Obviously BT results can only be as accurate as the initial estimates, since transferring values from a study site to a policy site necessarily increases the uncertainty in those values. When BT is used, the assumption is made that the cost incurred by carrying out a primary study at the policy site of interest would have been greater than the incremental value added from the improved accuracy of this primary study (Brookshire and Chermak in: Navrud and Ready, 2007). To check to what extent the estimation uncertainty is increased, so called "transfer experiments" could be performed. In "transfer experiments", original value estimates at the policy site are compared with transferred values. In this case, it is possible to test the reliability and validity of the BT estimates. Validity requires that the values or the value functions generated from the study site be statistically identical to those estimated at the policy site. This can be checked by applying various convergence tests. Kristofersson and Navrud (2004) recommend in this case using equivalence tests where the null hypothesis states the existence of differences between the original and transferred value estimates. Reliability requires that the differences between the transferred value estimates and the values estimated at the policy site be small, for example around 20-40% (Navrud and Ready, 2007). It could be tested by the so-called transfer error (TE) measurement in two ways: within-sample and out-of-sample:

$$(4)\quad TE = \frac{\left|WTP_e - WTP_t\right|}{WTP_e}$$

where: e – estimated/transferred value, t – true value (benchmark value at policy site, it is often approximated by conducting a primary survey at the policy site).

There could be different sources of transfer errors. Bergstrom and Civita (1999) define 5 categories:

- commodity measurement errors (e.g. when the commodity at the "study" site is different from that at the policy site, which could be reflected by different attributes),

- population characteristic measurement error (differences in socio-economic characteristics between “study” and “policy” site population),
- welfare change measurement error (refers to differences between welfare changes across studies, e. g, passive vs. active use, WTP vs. willingness to accept) ,
- physical-economic linkage measurement error (economic value estimated in a particular location and time may depend on linkages between biophysical functions or economic services)
- estimation procedure and judgment error (statistical estimation error, experts’ mistakes).

Some of these errors can be avoided at the stage of choosing the “study” sites to perform BT, e.g. by collecting all “study” sites where the same survey instruments were used or by choosing primary studies conducted more less simultaneously among similar population in terms of socio-economic characteristics.

But testing reliability and validity does not determine when the results of an implementation of BT can lead to a wrong policy recommendation. The level of BT accuracy required may differ depending on what the results will be applied to (see Figure 3).

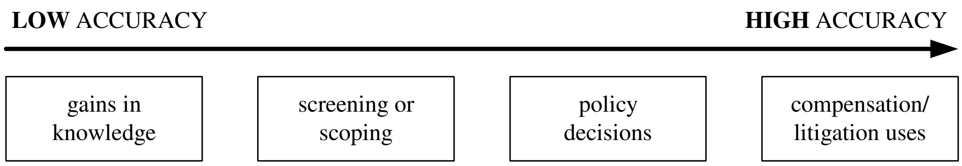


Figure 3. Level of accuracy required in BT analysis.
Source: Filion et al. (1998).

Bergstrom and Civita (1999) argue that inaccuracy in general knowledge gains costs society relatively little, whereas using biased estimations for determining compensation levels in the context of natural resource damage could lead to potentially irreversible losses of extremely scarce environmental attributes, such as endangered species.

## 5. How have non-timber forest benefits been transferred to date?

In Europe, unlike in the United States, BT is not so widely used by government agencies connected with forest management. The applications of BT are usually reported for internal purposes and not published in scientific journals.

In our review we focus on so-called forest "BT experiments" which examine the accuracy of BT estimates. We collected 19 studies – "transfer experiments": In 12 of them transfer only between forest sites is conducted, in the rest of them, many different environmental sites – including forest ones – are used to transfer value of either recreation or landscape.

Analyzing the first group – this based only on forest sites – we found that most of them deal with recreation, and therefore with use values (see Table 3). Two studies also transfer non-use values. Lindhjem and Navrud (2008) transfer values related to "changes in forest practices" (i.e. leaving more broadleaves trees, leaving dead wood etc.) and "forest protection programs" (i.e. full protection like a reserve). Some of the values transferred in this case are related to recreation and some to non-use, e.g. related to biodiversity protection. The other paper which transfers both use and non-use values is Loomis et al. (2005) where the values of a whole set of goods and services from "forest fire prevention programs" are transferred.

The studies cover a period of 11 years and all but two were conducted in northern European countries (Denmark, Great Britain, Republic of Ireland, Norway, Sweden and Finland). Three studies deal with international BT; however, the selected countries are similar in terms of geographical characteristics and cultural background (BT among Scandinavian countries – Lindhjem and Navrud (2008), and British Islands – Matthews et al. (2007) and Scarpa et al. (2007)).

Table 3. Summary of forest benefit transfer studies.

| Reference | Country | Function | Value | Study sites method | No. study sites | BT Method |
|---|---|---|---|---|---|---|
| Lindhjem, H., S. Navrud (2008) | Norway, Sweden, Finland | recreation/ changes in forest management | use/ non-use | CV | 26 | IAVT, MA |
| Moons E., B. Saveyen, S. Proost, M. Hermy (2008) | Belgium | Recreation | use | TC (GIS) | 32 | BFT |
| Leon-Gonzalez, R. and R. Scarpa (2007) | UK | Recreation | use | CV | 42 | BA+BFT |
| Matthews, D. I., W. G. Hutchison and R. Scarpa (2007) | Ireland, Great Britain | Recreation | use | CV | 42 | BFT |
| Scarpa R., W. G. Hutchinson, S. M. Chilton, J. Buongiorno (2007) | Ireland, Great Britain | Recreation | use | CV | 26 | CSAVT |
| Zandersen, M., M., Termansen, and F.S. Jansen (2007a - LE) | Denmark | Recreation | use | TC (GIS) | 52 | BFT |
| Zandersen, M., M. Termansen, and F.S. Jensen (2007b - JFE) | Denmark | Recreation | use | TC (GIS) | 52 | BFT |
| Loomis, J. B., Le, H. T. and A. Gonzales-Caban (2005) | USA | changes in forest management | use/ non-use | CV | 3[23] | BFT |
| Leon, J. C., F. J. Vazquez-Polo and R. L. Gonzales (2003) | Spain | Recreation | use | CV | 2 | BA |
| Leon, C.J, F.J. Vazquez-Polo, N.Guerra and P. Riera (2002) | Spain | Recreation | Use | CV | 3 | BA |
| Bateman, I. J., A. A. Lovett and J. | Great Britain | Recreation | Use | CV + TC | 1 | DFT |

[23] This number in this case means the number of analyzed populations (3 states: California, Florida and Montana). Number of sites was unspecified. Respondents were asked about 2 different forest fire protection programs undertaken in their county and state.

| | | | | | | |
|---|---|---|---|---|---|---|
| S. Brainard (1999) | | | | (GIS) | | |
| Lovett A. A., J. S. Brainard and I. J. Bateman (1997) | Great Britain | Recreation | Use | CV + TC (GIS) | 1 | DFT |

Notes: CV – contingent valuation, TC – travel cost, GIS – geographical information system, IAVT – income adjusted value transfer, CSAVT – conditional on site attributes value transfer, MA – meta analysis, BFT – benefit function transfer, DFT – demand function transfer, BA – Bayesian approach.

All the reviewed papers use primary studies based either on CV or TC methods. In most cases primary studies were carried out on-site. In the CV surveys, a payment vehicle is introduced as an entrance fee, and the elicitation method is the single or double bounded dichotomous choice (apart from Lindhjem and Navrud, 2008, the MA study). TCM is supported by the Geographical Information System (GIS) tool. In most studies the benefit functional transfer is used based on quite a large number of analyzed sites (in 7 articles, the number of sites varies from 26 to 52, and in the remaining 3 cases there are 1 to 2 sites). The authors of all studies from this group in which the TCM approach is used in primary surveys, carry out demand function transfer rather than benefit transfer. There are also examples of the Bayesian approach (2 studies: Leon-Gonzales and Scarpa (2007) and Leon et al. (2003)). In two articles, unit value transfer was applied (Lindhjem and Navrud (2008) and Scarpa et al. (2007)).

The BT forest literature which we collected varies very much in terms of the objectives of the research being presented, in spite of a relatively small number of articles and an investigation, in almost all cases, of the same type of good – forest recreation. Generally, the collected literature can be grouped into four broad categories according to the focus of study (some of the articles deal with more than one of these subjects):
(1) time aspect in transferring values,
(2) BT site adjustment for differences in forest physical attributes,
(3) the role of population characteristics in forest BT, and
(4) methodological improvements (GIS, Bayesian Approach).

Apart from BT, carried out purely for forest sites, we found a few studies investigating environmental value transfer in a wider natural recourse context. Mainly in these studies the value of outdoor recreation has been transferred (see Table 4) using MA regression. In all cases information was gathered from the United States and covers valuation studies in more or less a 30-year period. The main focus was on use value estimates for recreation activities defined by USDA Forest Service documents (21 activities[24]). The environmental sites distinguished other than forests were: lakes/reservoirs, estuaries/bays, river-based sites and parks (incl. mountains). This wide range of recreation categories can be linked with particular environmental sites (i.e. rock climbing, fishing) or seasons (i.e. cross-country skiing) or can refer to multiple sites (i.e. camping, picnicking). Depending on the recreation activities, forest recreation had higher or lower estimates than other sites (e.g. biking lower). Since forest sites specifically were not the main area of interest in carrying out MA in these cases, forest characteristics were not collected in the database and therefore not analyzed (apart from broad categories such as wilderness areas, public vs. private lands).

Table 4. Summary of outdoor recreation BT studies including forest sites.

| **Reference** | **Country** | **Sites** | **No. studies** | **No. of estimates** | **Primary study methods** | **BT Method** |
|---|---|---|---|---|---|---|
| Shrestha, R. K., R. Rosenberger, and J. Loomis (2007) | 1) USA<br>2) internat.[25] | forests, lakes/ reservoirs, estuaries/ bays, river based sites, parks | 1) 145<br>2) 159 | 1) 726<br>2) 765 | CV, TC | MA |
| Shrestha, R. K. and J. B. Loomis (2002) | USA | | 131 | 682 | | |
| Rosenberger, R. S. and J. B. Loomis (2002)[26] | USA | | 131 | 701 | | |
| Shrestha, R. K. and J. B. Loomis (2001) | international | | 159 | 765 | | |
| Rosenberger, R. S. and J. B. Loomis (2001) | USA | | 131 | 682 | | |

BT results were compared based on different aggregation levels showing for example that the national benefit transfer outperforms the regional one. Two international BT were conducted using a USA database

[24] Camping, picnicking, swimming, sightseeing, off-road driving, motor boating, float boating, hiking, biking, downhill skiing, cross-country skiing, snowmobiling, big game hunting, small game hunting, waterfowl hunting, fishing, wildlife viewing, horseback riding, rock climbing, general recreation, other recreation.

[25] Out-of-sample transfer based on MA for USA studies to "abroad" (28 studies from 14 countries, 83 estimates).

[26] Single point and average value estimates from the literature for hypothetical mountain biking were transferred as well.

and transferring values to each of the international studies collected (studies from 28 countries differ significantly in terms of economic and cultural situations as well as geographical location: Canada, Australia, New Zealand, Italy, UK, Belgium, Finland, Spain, Madagascar, South Africa, Kenya, Costa Rica, South Korea). In most cases the explanatory power of the meta regression function was relatively low, around 0.3. Some other studies were aimed at methodology and, for example, were investigating different convergent validity tests.

In addition we found two studies dealing with landscape value transfer based on different environmental sites, including forest sites (see Table 5.). These studies were based on CV estimates (Santos in Navrud and Ready, 2007) or on CE estimates (Colombo and Hanley, 2008). Both were carried out for a UK "policy" site.

Table 5. Summary of landscape BT studies including forests sites.

| **Reference** | **Country** | **Sites** | **Primary study methods** | **BT Method** |
|---|---|---|---|---|
| Colombo, S. and N. Hanley (2008) | UK | heather moorlands and bogs, rough grasslands, broad and mixed woodlands, field boundaries, cultural heritage | CE | VT, BFT |
| Santos, J. M. L (2007) | UK/ international | Flower rich meadows, broadleaf woods, stone walls | CV | VT, I&FAVT[27]*, BFT, MA |

* Income and CV format adjusted value transfer

Reliability and validity in all collected studies are tested in various ways by using different convergence tests or measuring marginal or average transfer errors. The authors usually perform a few subset transfer experiments, dividing collected studies according to the methodology used and estimations used in primary studies (e.g. median vs. mean, single bound vs. double bounded format), differences in BT methodology (e.g. different forms of BT functions, different BT approaches, an acknowledgment of forest characteristics vs. lack of it, updating information on the demand function in temporal transfer vs. unchanged information) in environmental programs (i.e. mechanical fuel reduction vs. prescribed burning), differences in forests attributes (i.e. most valuable vs. less valued, closer to cities vs. further away), or information concerning target groups (e.g. socio-economic

[27] I & FAVT based either on estimations from a single best study or multiple studies.

differences between inhabitants of three states). To test the accuracy of estimates, most authors used different convergence validity tests to check the equality of BTF predicted and original mean WTP/CS values, and to test correlation and regression. No one performed the equivalence test recommended by Kristoferson and Navrud (2002) (hypothesis zero – there is a difference between surveys). In a few cases, analyses were performed using percentage differences (transfer error measure) within or out of sample.

## 6. Experiences and challenges from the transfer of non-timber benefits.

### 6.1. Why has the value of recreation so far been mostly transferred in the forest context?

Looking at articles dealing with BT in the forest context, it is easy to note that in most of them the value of recreation has been transferred and other non-timber goods and services have been omitted, with the small exception of biological diversity. There could be several alternative explanations for this:

(1) Recreation is the most important non-timber forest function for practitioners and planners, since individuals value this function the highest. This statement can be supported by some evaluation results, for example Willis et al. (2003) where in a British national forest survey, recreation was found as the most precious item in terms of annual value among forest non-market goods and services (the other functions considered were landscape value, biodiversity, carbon sequestration and air pollution absorption). However this ranking can vary in different countries, since for some countries historical and social circumstances may imply higher frequencies of forest visits or higher values placed on these visits than in the others.

(2) Recreation is the easiest to value of all non-timber goods and services using valuation methods based on either RP or SP. Recreation belongs to the group of direct-use forest NTBs values, whereas the rest of forest non-market functions have either indirect use values (ecosystem services) or non-use values. Apart from that, outdoor recreation, unlike the rest of NTBs (especially biological diversity ), is not so controversial to define. Both of these factors indicate why it is relatively easy to construct valuation survey and estimate values, in this case comparing with the rest of forest non-market functions. But at the same time there could be strong linkages between recreation and the other forest functions, such as aesthetic value or biological diversity. Additionally, with recreation, the values can be achieved by carrying out TCM surveys and, as mentioned before, RP functions characterized by higher

explanatory power in general than SP ones, and it could be another argument for basing BT experiments on recreation instead of other NTBs.

(3) The third reason can be derived from the previous ones: the majority of forest non-market primary studies concentrate on recreation, so if one wants to do BT experiments here is the biggest set of surveys to choose from. For example, Elsasser et al. (2008) state that from 86 data sets for France, Germany, Austria and Switzerland more than half refer to recreation. In the case of some forest functions like watershed services, the evaluation methods like avoided, damage or substitute costs are often used, which are not so costly and time consuming as methods based on RP or SP and in this case conducting BT would not be justified.

(4) It is an important issue to be aware of different interactions between forest functions (substitutable or complementary) but above all, clear definitions of them are needed. Sometimes – in primary valuation surveys the whole "package" of different forest functions is valued – there is no way for a reasonable division of achieved outcomes into subcategories. In this case, coding results in non-market valuation databases according to all categories could be subject to interpretation of results and then it could make later BT outcomes biased. If we deal with non-use values – e.g. an evaluation of endangered species – it is more difficult to conduct BT due to problems with establishing the proper unit measurements which can in many cases be strongly linked to the initial level of environmental quality.

### 6.2. How to deal with the time issue in forest BT context

In BT, the time aspect is often present since in most cases is based on using historic data to transfer present values – so we actually deal with a temporal transfer. The problem of time differences between study site and policy site can only be avoided when both of them take place in the same period – which is rare. While in BFT and a value transfer based on one survey the time adjustment would refer only to one period of time, with MA-BT and value transfer based on many surveys there would be more time differences to deal with.

The time aspect is important for at least three variables: differences in income level, differences in consumption preferences and behavioral patterns, and changes in environment. All these aspects are linked with each other. Where the first issue can be relatively easy to correct (using the elasticity index between environmental value and the income level[28]), the other two constitute big challenges for researchers since:

- preferences are known to be unstable over time. This concerns the forest in terms of individuals' preferences towards some forest attributes such as species diversity and age over a long period (Zandersen et al. 2007a). However, Loomis (1989) finds that WTP is relatively stable over the period of nine months which he investigated,
- behavioral patterns depend on many factors – one of them could be technological development (e.g. visiting more distant places because of the change in transport modes allowing faster travel and time saving),
- changes in environment and their welfare estimates vary in time and a lot of environmental projects – including forest – have long-term durations (40-80 years after project start, for example: afforestation, wilderness preservation, or ecosystem restoration).

When future projects are considered, an evaluation of their benefits is not possible by applying the revealed preference methods such as TCM. Navrud and Brouwer (2007) claim that in general, WTP functions based on SP surveys – especially CV – have much lower explanatory power than functions using RP methods, so it could be more relevant to use revealed preference primary studies than transfer estimates. So if one places more trust in RP estimations than stated preference methods, the only solution in this case is to transfer welfare estimates from primary TC or HP studies. This issue in the forest context is very important, for example when BT estimates are going to be used in CBA for establishing new recreation sites. And since many of forest projects are characterized by a long duration, the correct capture of changes over time in a relationship between environmental value and individuals' income and preferences remains a crucial aspect.

There is an impression that in forest BT exercises, not enough attention has yet been devoted to the time aspect. In most of the reviewed papers the data used comes from the same period (e.g. Scarpa et al. (2007) test BT based on almost simultaneous – a period of a few weeks– collections of CVM data from 26 forest sites) or there is an assumption regarding the lack of time differences (e.g. Moons et. al (2008) assume in their model of optimal allocation of a new forest site that all projects started at the same point in time). Lindhjem and Navrud (2008) consider the time aspect only as a change in income levels and adjustment values in their MA and unit value transfer according to the inflation (implicit price deflator) and addining a time trend (year as an explanatory variable) to the regression

[28] Navrud and Brouwer (2007) claim that income elasticity of WTP for different environmental goods are typically smaller than 1, and often in the 0.4-0.7 range.

function. The same approach is used in all outdoor recreation BT papers collected.

But there are a few studies testing temporal transferability. The time aspect in a forest recreation transfer is the main topic of two Danish papers (Zandersen et al. (2007a) and (2007b)). They test the reliability of benefit transfer of forest recreation values over a 20-year time horizon. Both studies are based on a survey carried out in 1977 among respondents visiting 52 selected forest sites. The benefit function is used to estimate a recreation value of one these forests in 1997. In the first paper (Zandersen et al. (2007a)), the authors conduct two different transfers based on two different models: in one of them only the information collected in the 1977 survey is used to assess the recreation value in 1997, whereas the other one includes updated information about demand structures using information from a national household survey in 1994 (but keeping trip patterns from 1977). The authors find that preferences for some forest attributes, such as species diversity and age as well as transport mode, have changed significantly over this period and updating transfer models by including more recent information about demand for forest recreation allows significant reduction in transfer error (improvements in error margins by an average of 282%). They conclude that the BT over time can be reliable (may produce acceptable errors[29]) as long as it is adjusted to changes in preferences and behavioral patterns.

In the other paper (Zandersen et al. (2007b)), the authors concentrate on changes attributed to forest recreation values along with a time flow. They find that the recreation value over a 20-year period of a large, newly established fringe forest increased 70 times, mainly due to the maturing of the forest. The second reason is related to a change in the patterns of visitors' behavior. The benefit transfer estimations over time give results of between 57% underestimations and 349% overestimations depending on the sampling of the choice set used as the study site.

### 6.3 Heterogeneity of forest sites and environmental changes

It is hard to find two environmental goods which are identical, and forest sites are no exception. In BT methodology, the important issue is how the physical differences between forests sites affect the accuracy of a value transfer. Even though we know fairly well which types of forest attributes people generally prefer from many quantitative surveys (Gundersen, V. S. and L. H. Frivold (2005), Lindhagen and Hørnsten (2000), Ribe R. G. (1989)), people's WTP for such attributes are less well known. So the first question is: what forest characteristics influence individuals' WTP for forest

[29] Average error of the best transfer model was around 25%.

non-market good and services? Another would be: how to deal with forest heterogeneity when performing BT? Regarding the first problem, there is still no sufficient evidence about a relationship between forest attributes and the WTP or CS of certain forest functions (recreation, ecological services etc.) The results from primary studies are usually based on one or a few sites, which is not enough to establish such general relationships reliably. Size of forest site is a good example here. Some authors claim that it could be positively related with WTP for forest recreation (Mattews et al, 2007), but others (Lindhjem, 2007) find that there is no such dependence. Moons et al. (2008) say that small forests (less than 20ha) attract few to no visitors and in the case of large forests (more than 300ha) an increase of 1 ha causes negligible change in visitor numbers. But their statement is based on a forester's opinion, not on empirical research. Even less attention in the literature is devoted to the forest management role and to the existence of other natural tourist attractions inside forests, like lakes or mountains, and their impacts on outdoor recreation. At the same time it is worth noting that a single forest might not be homogenous itself. A single site can consist of different parts which could vary in terms of biological diversity or management regime (this could be a case of either study site or policy site or both), making BT an even more complicated task.

Colombo and Hanley (2008) point out that the inclusion of three similarity indicators (disposable income, land cover and geographical distance) in the selection of study site may lead to a reduction in transfer errors, although no clear pattern emerged. However, they also note that there are no clear criteria that define the concept of required "similarities" between study and policy sites. They show that adding more information to BT does not always reduce transfer error (the experiment of adding new sites which are more different in disposable income and landscape abundance makes transfer error worse). Santos (2007), applying different BT approaches and models, finds that the most accurate transfers are the VT based on single best study (chosen by experts – qualitative landscape change is similar in "study" and "policy" case, and additionally the visual presentations in both cases are almost identical) adjusted to DC format and meta-analytic models when predicting the DC format.

In part of our reviewed studies, forest characteristics are neglected in the analysis (Moons et al. 2006, Bateman et al. 1999, Lovett et al. 1997), however they are the main subject of a few others. Scarpa et al. (2007) and Matthews et al. (2007) investigate site-adjusted benefit transfer in a forest recreation context. In the first case, it is a site-adjusted value transfer (the transfer takes place after an adjustment which accounts for differences between attributes relevant to recreation across study and policy sites). The other study focuses on the site-adjusted benefit transfer function approach (this approach attempts to explain variations in WTP for forest recreation on the basis of variations in forest attributes).

Scarpa at el. (2007) claim that unlike the unconditional value transfer, value transfers conditional on site-specific recreation attributes are mostly transferable (reliable when forest attributes are used as predictors). They found that forest attributes show significant and plausibly signed coefficients. The forest attributes analyzed in this case were size of forest, conservation regime (nature reserve vs. others), age and share of tree coverage. Matthews et al. (2007) notice that insufficient data collection explaining the relationship of benefits to change in site attributes remains the main limitation of BT studies so far. They conclude that for a benefit function to perform well, the function must capture differences in welfare values between sites and if the site attributes are poorly chosen, or the BTF is poor, than the pool of sites needs to be large enough to incorporate the range of available sites. Scarpa at el. (2007) also point out that when benefits are determined by site attributes their omission from the econometric specification of BT results in mis-specification errors: but on the other hand, the inclusion of these attributes may cause co-linearity since all observations from the same site are associated with the same set of value attributes and for this reason the BTF estimation in this case should be achieved with data from a sufficiently large number of sites. Leon-Gonzales and Scarpa (2007) also note that reliable estimates in BT can be obtained when the heterogeneity between sites is appropriately captured by the model but at the same time they propose a Bayesian Model Averaging Approach which, if the sample size for a particular site is small, provides credible intervals by combining a BT estimate with a site specific estimate. Zandersen et al (2007a) and (2007b) implemented the Random Utility Model (RUM) in their calculation to solve the problem of non-similarity across sites since it can include multiple site characteristics.

Not only can differences in physical forest attributes influence the credibility of BT results, but also the environmental changes described in “study” and “policy” sites. And again in rare cases analyzed, environmental changes can be expected to do the same. They can vary in terms of magnitude and direction. Navrud and Brouwer (2007) claim that people place a higher value on keeping the original/undisturbed environmental good than on restoring it. Particularly, this problem can apply to “study” estimates collected from many studies such as a MA-BT case.

### 6.4. Spatial consideration

Benefit transfer is intrinsically concerned with space, because it consists in taking into account two different sites, the study site and the policy site, which differ by their location. This issue is particularly present when we consider international transfers, since there is a higher probability that in this case we will find more difficulties connected with the different geographical locations of analyzed sites. Firstly because of differences in forest characteristics such as density, dispersions, types of forest, the quality of forest ecosystems etc., and secondly because of cultural differences and forest use traditions (including the distribution of public and private forests and their availability to the public), and thirdly because of differences in income levels between countries.

This last factor is relatively easy to correct by using Purchase Power Parity (PPP) corrected exchange rates. The first one refers to the problem of the relationship between WTP or CS and forest characteristics including forest location and the existence of substitute sites (forest dispersion). Geographical Information Systems (GIS) can be a helpful tool to analyze this aspect. The GIS approach put together spatial data, software applications and quantitative analysis and represents a means to organize and to store information that is referenced to the earth. Troy and Wilson (2006) note that this tool allows comparisons between study sites and policy sites considering three critical factors: the biogeographical similarity of the two sites, the human population characteristics and links with the environmental service, and the level of scarcity of the service (existence of substitutes). Viewing forest ecosystems on a spatial dimension allows analysis of them in terms of location, distribution and characteristics, in other words better accuracy in the site description. Elaboration of spatial scales when valuing ecosystem services also seems important to understand WTP in primary studies.

In the forest context, an estimation of the recreation demand function using GIS has been developed by Lovett et al. (1997) and Bateman et al. (1999). Their results show that an application of GIS in BT improves efficiency and consistency. In Lovett et al (1997) the analysis is extended by including such factors as availability of substitutes to the demand function. In both papers, the analysis is limited to establishing one forest site. Moons et al. (2008) transfer the estimated forest recreation demand function to the multiple new forest sites. They also check how recreation benefit depends on substitute sites, concluding that the availability of substitutes has a significant effect on the recreation value of a forest.

Troy & Wilson (2006) note a difference between spatial data and economic valuation data, the first being more and more precise and of high quality and the second not being sufficiently representative of a large variation. The consequence of these inadequacies in quantity and quality does not allow any relevant transfer.The last factor – cultural differences and differences in traditions of using forest - seems to be an unsolved problem, however. Not considering this issue can lead to wrong inferences. An example could be the UNECE/FAO [2005] report which concludes that the value of a recreational visit to forests in Eastern Europe is 0.25 EUR, based on simple unit value transfer adjusted only to income level from estimates from Western Europe. Bartczak et al. (2008) find this value to be around 7 Euro from a TCM primary study administered on-site, in ten selected forest areas in Poland. It seems reasonable to restrict environmental value transfer between countries to those that are similar in terms of geographical location, cultural and social background, as well as in forest management methods.

## 6. Conclusions

The benefit transfer approach has become an increasingly practical way to assist in decision-making when primary data collection is not feasible due to budget and time constraints, or when resource impacts are expected to be low or insignificant. However, the academic debate on the validity of the methods still continues. We decided to investigate the BT application in the forest context analyzing "transfer experiments" where original benefit estimates at the policy site were compared to estimates transferred from other sites. Evaluating different environmental services – not only timber production – is an important aspect of multifunctional forest policy.

Although the forest delivers many environmental functions, reviewing forest BT studies we found out that recreation is a topic of most of them whereas less attention is devoted to other forest function– especially those connected with non-use values. Because all primary valuation estimates but one came from either CV or TC surveys. The only study using Choice Experiment benefit estimates concentrates on landscape value and performs a transfer among different environmental sites, one group of which constitutes forest sites. In the context of "pure" forest transfers, the preferred technique was functional transfer based on estimation from many sites, although some authors (Colombo and Hanley (2008), Lindhjem and Navrud (2008)) find that value transfers are not consistently outperformed.

In some cases, collecting a wide range of data helped to deal with site heterogeneity, which is one of the key issues in forest BT as well as in BT in general. Nobody disputes that adjusting BT to site characteristics improves the transfer results, but which forest attributes have an important influence on welfare estimation still needs further investigation. Similarity not only between sites but spatial location should be considered in BT as well, since, for example, not only the aggregated area of forest sites but also their different dispersion can bias the BT outcomes. In this context, tools like GIS can be very helpful. At the same time, selection of the study sites from which the value is transferred can affect BT validity. However, adding more information to benefit transfer estimations will not always reduce transfer errors. The studies based on many environmental sites (other than just forests) do not highlight the role of forest site characteristics.

The time aspect is another important issue for BT in general as it is known that preferences and behavioral patterns vary over time. In the forest context, additional problems appear with the fact that values evolve with environmental changes, e.g. forest age. And a lot of forest planning is long term, so variations in benefit estimates have to be expected. So far, only two forest BT papers have been devoted to this matter (Zandersen et al. 2007a and 2007b). In other cases, time gaps were "cured" by an adjustment to the inflation index, without using the WTP/CS elasticity according to income changes.

Our review summarizes 12 years of research on BT application in the forest context and shows the challenges remaining in this area to increase the precision, accuracy and reliability of transferred estimates.

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# Effects of reforestation cost sharing in Norway

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## Abstract

This paper studies effects of public cost sharing on reforestation in Norway by applying various econometric specifications to a large panel of Norwegian non-industrial forest owners for the period from 1993 to 2003. Using both average estimators and estimators with individual specific unobserved effects allows for revealing both long and short term effects. To control for heterogeneity we estimate separate models for different sub samples according to property size. The results reveal considerable heterogeneity, with reforestation responses varying with property size. In the short run it seems that public support mainly affects the discrete decision to undertake reforestation measures rather than the continuous decision of reforestation intensity. The long run effects of public support are moderate.

Keywords: forest owner behaviour, reforestation, cost sharing, panel data, tobit, random and fixed effects

# Income effects in choice experiments

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## Abstract

In a choice experiment we test income effects for different attributes and we test the effect of stated expected changes in future income on stated WTP. We find both present and future income to be significant determinants of stated WTP when included in the same model. We also find that the less use-related the attribute, the stronger the income dependency, both in terms of present and future income. The finding that expectations concerning future income affects WTP seem to suggest relevance of the life cycle-permanent income hypothesis also for environmental goods, and it suggest that the current practice of testing for income effects using current income only is likely to be flawed. This may be particular true if the good in question and/or the payment vehicle used have long time horizons.

**Keywords:** Stated preferences, income elasticity, life time income, environmental valuation, wildlife

## 1. Introduction

Do emphasis on environmental goods and services increase with increasing income, and if so is this reflected in an increased willingness to pay for improvements in such goods? It is widely believed to be the case and in fact income sensitivity of WTP-measures is often seen as an indicator of validity and reliability (Mitchell & Carson 1989) of stated preference studies, as it may indicate whether respondents take the budget constraint serious. Many studies fail to find such a relationship (Jacobsen & Hanley, 2008), and even where found, the actual - often small size - has caused a debate on how large it should be (Bateman et al. 2002). Arguments have been given for environmental goods to be progressively, with an income elasticity of WTP larger than one, but more often they seem to be regressively distributed (Kriström & Riera, 1996), implying that even if WTP increases by income this is less than proportional. However, this does not explain why there are so many studies in which an income effect seem absent.

A potential reason for this, which we focus on here, is that the income measure commonly applied, which is current income as reported by respondents, may in fact not be the one respondents have in mind. In particular, invoking the general thoughts of the life cycle-permanent income hypothesis (Friedman 1957), we may expect respondents to take future income into account when answering hypothetical WTP questions. When the payment vehicle used furthermore suggests that payments will continue either for a specified amount of years (e.g. Amigues et al, 2002) or an unspecified period (e.g. Jacobsen et al., 2008a) into the future, such considerations may be even more likely than for once-and-for-all payments. Furthermore, environmental protection often has a very long time perspective, especially for non-use values such as existence values and bequest values. Thus, as also the derived benefits for the individual reaches into the future, it could be argued that the payment period has to be in accordance with the benefit period (for the individual) and if so, also the considered income.

These considerations leads to the main hypothesis tested in this paper: Do respondents consider future income as well as current income when they answer WTP questions? By the use of a choice experiment (CE) with follow-up questions concerning current income level in quantitative terms and their expected future income relative to current income, we are able to test this hypothesis for attributes with different degrees of use and non-use values. We also discuss the size of the income effect in relation to income elasticity of WTP for different attributes.

**1.1 Literature**

In most stated preference studies it is tested whether the results are sensitive to income, and it is often also reported. Examples of significant income parameters are Riera et al. (2008), Bandera and Tisdell (2004), Sattout et al. (2007) and examples of insignificant parameters are Holmes et al. (2004), Jacobsen et al. (2008a), Leon (1996). In a meta-analysis Schläpfer et al (2006) find that 63% of the studies, which report income effects, found positive effects. In another meta-analysis Jacobsen and Hanley (2008) find that 56 of 145 data points reported internal significance of income as an explanatory factor for WTP, whilst 39 reported insignificant effects. Thus even if income effects are seen as a test of validity, studies failing this test still get published.

A reason for this may be due to the lack of consensus concerning the theoretical dependency of WTP-measures on income. It has long been argued that environmental quality is a luxury good, with an income elasticity of demand greater than one (Kriström and Riera, 1996). If this is so, then demand for environmental goods, manifested either as consumers buying greener products, or demanding tougher environmental legislation, will grow disproportionately quickly as incomes rise. However, both

Kriström and Riera (1996) and Hökby and Söderqvist (2003) question this assumption and find regressive distributions.

Most goods valued using the kind of stated preference methods upon which Kriström and Riera base their conclusions are public goods which are in fixed (rationed) quantities from the perspective of the individual, so that the individual cannot continuously vary the quantity of goods he or she demands. Thus instead of using the measure of income elasticity of demand, the measure of income elasticity of WTP is used (for descriptions see (Flores and Carson, 1997; Hökby and Söderqvist, 2003). For non-use values derived from public goods, this seem particularly compelling, but also use-based recreational values limited by e.g. access rights cannot be freely on the demand side. The environmental improvements described for respondents in this study largely have these characteristics, and hence we focus on the income sensitivity of the WTP-measure.

In all the studies mentioned above where income was insignificant the duration of the payment was infinite (payment per year for an undefined time) and the good in question was mainly related to non-use values with a long time horizon. Furthermore, in all the studies, the income measure used for estimating income effects is current income. This stands in strong contrast to the general economic literature on consumption, income and wealth, where consumption propensities are only rarely believed to be dependent only on current income levels. This economic literature takes its theoretical starting point from Friedman's (1957) permanent income hypothesis, which was immediately put to test and disputed (Houthakker 1958a, b; Eisner 1958; Friedman 1958). Since then the framework has been extended and known as the life-cycle permanent income hypothesis and put to several tests (Hall 1978; Campbell 1987; Gourinchas and Parker 2002), and is now widely acknowledged as a theoretical cornerstone in trying to understand consumption choices. According to the hypothesis, consumers form expectations of their ability to consume in the long run, and then set their current consumption to what they think is the appropriate fraction of the long-run expectations. Empirical tests of this hypothesis have obviously struggled with the definition of variables capturing consumers' long-run expectations, and the hypothesis is still contested on its predictive power.

To us, however, it seems reasonable that stated WTP for environmental services could in fact also reflect such considerations. Note that if this is the case then this could perhaps explain the often weak or non-existent sensitivity of WTP to income found in environmental valuation literature. The reason is that current income is for some groups a poor predictor of long-run consumption options. In the low income brackets we find young people, e.g. university students and the like, which have a low current income but may expect future income to be much higher. Thus, their

WTP may be relatively higher than their low income would suggest. Similarly, we may find in the high income brackets people who are thinking of their retirement age and pension funds. Their WTP may be relatively lower than their high income would indicate. It is easy to see that such a systematic variation could be devastating for any income sensitivity of WTP to materialise it self. To test this hypothesis: That WTP reflects not only current income but also expectations concerning future income, we perform two quite crude and simple test: First, in addition to asking respondents for their current income, we ask them to indicate if they think their future income will be lower, similar or higher than their current income level. We apply this information in an analysis of the WTP sensitivity to both measures simultaneously. Secondly, we single out respondents that are either students or in an age bracket likely to be working but facing retirement in not too many years. We explore the WTP patterns of these groups relative to other respondents.

## 2. Material and Method

In a CE study of environmental goods, respondents are asked to choose between sets of pre-defined alternatives, with changes in attributes of the environmental good, where each alternative is connected with different cost levels. Respondents are requested to select their preferred alternative, and under the assumption that the individuals make choices to maximise their utility, subject to resource constraints, the method gives a very powerful framework for creating economic models of choice and eliciting WTP for preferences (Wooldridge, 2002). The CE method was originally developed for market analysis (Louviere et al., 2000) and it relies on McFadden's (1974) random utility model, where the utility of a good is described as a function of its attributes and people choose among complex goods by evaluating their attributes. Since observation of utility can only be made imperfectly, the random utility model is the fundament for estimation and can formally be described as:

$$U_{ij} = V_{ij}\left(y_i - t_j, x_j, z_i,\right) + \varepsilon_{ij} \qquad (1)$$

The term $U_{ij}$ is the $i$'th individual's utility of paying $t_j$ out of individual income $y_i$ for the good described by alternative $j$. $V_{ij}$ is a deterministic term depending on the alternatives' attributes $x_j$, the individual's characteristics, $z_i$. The term $\varepsilon_{ij}$ is stochastic in the sense that its variation cannot be observed by the analyst. Faced with the choice between two alternatives, the probability that the respondent will choose alternative $k$ (over alternative $j$) can then be described as:

$$\Pr_{ki} = \Pr\left( U_{ki}\left(y_i - t_k, x_j, z_i, \varepsilon_{ki}\right) > U_{ji}\left(y_i - t_j, x_j, z_i, \varepsilon_{ji}\right) \ \ \forall j \neq k \right). \qquad (2)$$

Here $U_{ki}$ is the utility of alternative $k$, $U_{ji}$ of alternative $j$. The other parameters are as above. It is assumed that $U$ is linear in income and the remaining known variables of $U_{ki}$ are replaced with $\beta' x_{ki}$, where $x_{ki}$ represents a vector of variables related to alternative $k$ that we are able to observe. Also, assuming that $\varepsilon_{ki}$ is IID extreme value distributed the probability of an individual $i$ choosing alternative $k$ can be defined by the Conditional Logit model:

$$\Pr(ki) = \frac{\exp^{\beta' x_{ki}}}{\sum_j^J \exp^{\beta' x_{ji}}} \tag{3}$$

Following Train (2003) the Mixed Logit probabilities can be described as integrals of the standard conditional logit function over the distribution of $\beta$. If the distribution of β is specified to be normal the probabilities of the model becomes:

$$\Pr(ki) = \int \left( \frac{\exp^{\beta_i' x_{ki}}}{\sum_j^J \exp^{\beta_i' x_{ji}}} \right) \phi(\beta | b, W) d\beta \tag{4}$$

where $\phi(\beta | b, W)$ is the distribution function for $\beta$, with mean $b$ and covariance $W$. The analyst chooses the appropriate distribution for each parameter in $\beta$. This standard setup is applied to the CE data analysed here.

## 3. Survey design

The survey used a postal questionnaire and it focused on access to and wildlife in three widespread Danish habitats; forests, open fields, and lakes and streams. Along with the questionnaire, respondents were supplied with an information sheet describing current status of wildlife and access. The questionnaire was designed on the basis of discussions with experts in wildlife and tested in focus groups as well as in individual interviews. The first part of the questionnaire concerned the respondents' attitudes to nature and wildlife and level of recreational use and wildlife experiences. This was followed by the CE part and the third and final part of the questions concerned debriefing and the respondent's socioeconomic characteristics[30].

The CE included 2 × 6 choice sets, where respondents were distributed to two out of three habitats. Across blocks, the combination and order of habitats were distributed systematically to avoid order effects and ensure equal representation. Each choice set consisted of three alternatives, the first alternative always representing the status quo. The attributes describing each alternative included *i*) initiatives to increase population size of wildlife in general, *i*) initiatives to increase population size of endangered

[30] A translated version of the questionnaire can be obtained from the authors upon request.

wildlife and *iii*) various reductions in access to the habitats for the public in order to improve living conditions for wildlife. Respondents were explained that the increased expenses due to improvements would be financed by income taxes. Today, all similar public actions are funded in this way, giving credibility to the choice of payment vehicle in this specific context. The full set of attributes and levels are described in Table I.

Three attributes had three levels of provision and the cost attribute had six levels of provision. A complete factorial design would involve 162 combinations of alternatives for each habitat. We used a fractional factorial design. The same design was used for the three habitats, but allocated to respondents by a cyclic design to even out order and combination effects.

**Table I Attributes and levels in the CE questionnaire**

| ATTRIBUTE | LEVEL | VARIABLE |
|---|---|---|
| ACCESS: Access to habitat | Unrestricted access (status quo) | N/A |
| | Reduced access (No access in 25% of all of the specific habitat from April to November) | *HABITAT_REDACC* |
| | No access (No access in 25% of all of the specific habitat all year) | *HABITAT_NOACC* |
| THREATENED: Increases in population size of a threatened species related to the habitat | Threatened with extinction (status quo) | N/A |
| | Rare, but not threatened with extinction | *SPECIESNAME_RARE or THREATENED_SPECIES_RARE* |
| | Common | *SPECIESNAME_COMMON or THREATENED_SPECIES_COMMON* |
| GENERAL WILDLIFE: Increases in population size of general wildlife in the specific habitat | Population size as of today (status quo) | N/A |
| | Population increase by 25% | *HABITATNAME_25 or GENERAL_WILDLIFE_25* |
| | Population increase by 50% | *HABITATNAME_50 or GENERAL_WILDLIFE_50* |
| COST: Annual tax increase | 0 (status quo)<br>100 DKK<br>250 DKK<br>500 DKK<br>1,000 DKK<br>2,000 DKK | *TAX* |

*(100 DKK equates approx. 13 Euro)*

The design also involved an external test of scope. These results will not be reported here. Furthermore, some respondents received an ‘iconised’ description, where a specific species was shown as an example of general wildlife (cf. terminology in (Jacobsen et al., 2008a)) and others a more general description of the types of species. Also, the order of the attributes in the choice sets were varied, to even out any order effects. In this paper, we pool the data from the iconised version with the other version and we pool the data across habitats.

The threatened species used for the questionnaire was a Dormouse (*Muscardinus avellanarius*) for the forest, a Barn owl (*Tyto alba*) for the field and the Otter (*Lutra lutra*) for the lakes and streams. The iconised representatives of general wildlife was Hare (Lepus capensis), Great Crested Grebe (Podiceps cristatus) and Great Spotted Woodpecker (Dendrocopos major) The species may not have entirely equal appeal in terms of charisma, but all of them have had some degree of media attention.

At the end of the questionnaire respondents were asked to state their present household income level by ticking suitable quantitative brackets. Furthermore, they were asked to indicate if they expected their household's aggregate income before tax in ten years time to either be lower than, equal to or higher than the household's current income level.

In Denmark there is a fairly open access to most habitats for ordinary recreational activities like walks and biking along paths etc. Therefore, we expect respondents to react with demands of compensation for reductions in their access to habitats, even if explicitly motivated by concerns for wildlife protection, e.g. moderate reductions during the breeding season. Such reductions in access are commonly implemented in various specific localities, and thus this attribute should add plausibility to the overall case description.

The questionnaire was sent out to a representative sample of 1,800 people in May 2005 and 862 questionnaires were completed and returned which equals an overall response rate of almost 48 per cent. 116 of these dealt with the external scope test and is thus excluded in the analysis here. The full sample thus consists of 746 respondents answering 8,447 choice questions, as not all respondents completed all 12 choices.

## 4. Results

The results presented below are based on all habitats pooled together. Analyses on each habitat was also performed and showed the same results, although many of the parameters were insignificant due to fewer observations. No systematic difference was seen across the habitats for the patterns analysed here.

Initially the results were analysed by a conditional logit. Performing a Hausman test of elimination of the status quo showed that there were problems with IAA, and consequently random parameter logit estimation was performed instead. However, results of coefficient values do not differ much between the two models.

Stated household income was tried modelled both on a continuous scale of income groups in intervals of 100,000 DKK from DKK 0 to above DKK 700,000 and in three groups, below DKK 300,000, DKK 300,000-

700,000 and above 700,000. Results for the grouped model are used in the following. The continuous scale model also showed similar significant effects.

Expected changes in future income were dummy-coded if expected to be higher or smaller (as opposed to unchanged). Both present income and expected change in future income is crossed with each attribute, resulting in the estimates shown in Table 2 below. Only access crossed with future income is eliminated as they are non-significant and causes other variables to be less significant.

**Table 2. Parameter estimates for a mixed model with present and future income parameters**

| | | | | | |
|---|---|---|---|---|---|
| LL | | -8349.13 | | | |
| $\chi^2$ | | 15.89 | | | |
| P> $\chi^2$ | | 0.725 | | | |
| | | **Coefficient** | **Std.error** | **Z** | **P> \|z\|** |
| ASC | | 0.110 | 0.068 | 1.63 | 0.10 |
| Price | | -0.146 | 0.005 | -27.15 | 0.00 |
| Red. Access whole year | | -0.523 | 0.081 | -6.42 | 0.00 |
| -heterogeneity | | 0.006 | 0.362 | 0.02 | 0.99 |
| Red. Access summer | | -0.290 | 0.073 | -3.94 | 0.00 |
| -heterogeneity | | 0.052 | 1.006 | 0.05 | 0.96 |
| Common wildlife + 25% | | 0.639 | 0.091 | 7.00 | 0.00 |
| -heterogeneity | | 0.004 | 0.539 | 0.01 | 0.99 |
| Common wildlife + 50% | | 0.552 | 0.091 | 6.07 | 0.00 |
| -heterogeneity | | 0.027 | 0.404 | 0.07 | 0.95 |
| End. Wildlife threatened | | 1.145 | 0.100 | 11.40 | 0.00 |
| -heterogeneity | | 0.121 | 0.892 | 0.14 | 0.89 |
| End. Wildlife common | | 0.870 | 0.095 | 9.13 | 0.00 |
| -heterogeneity | | 0.650 | 0.513 | 1.27 | 0.21 |
| **Low income x** | | | | | |
| | Red. access whole year | 0.324 | 0.124 | 2.62 | 0.01 |
| | -heterogeneity | 0.006 | 0.362 | 0.02 | 0.99 |
| | Red. access summer | 0.080 | 0.109 | 0.73 | 0.46 |
| | -heterogeneity | 0.052 | 1.006 | 0.05 | 0.96 |
| | Common wildlife + 25% | -0.457 | 0.102 | -4.50 | 0.00 |
| | -heterogeneity | 0.004 | 0.539 | 0.01 | 0.99 |
| | Common wildlife + 50% | -0.691 | 0.099 | -6.99 | 0.00 |
| | -heterogeneity | 0.027 | 0.404 | 0.07 | 0.95 |
| | End. Wildlife threatened | -0.554 | 0.116 | -4.79 | 0.00 |
| | -heterogeneity | 0.121 | 0.892 | 0.14 | 0.89 |
| | End. Wildlife common | -0.427 | 0.123 | -3.48 | 0.00 |
| | -heterogeneity | 0.650 | 0.513 | 1.27 | 0.21 |
| **High income x** | | | | | |
| | Red. access whole year | -0.029 | 0.140 | -0.21 | 0.84 |
| | -heterogeneity | 0.129 | 1.782 | 0.07 | 0.94 |

| | | | | |
|---|---|---|---|---|
| Red. access summer | -0.046 | 0.114 | -0.41 | 0.69 |
| -heterogeneity | 0.002 | 0.665 | 0.00 | 1.00 |
| Common wildlife + 25% | 0.039 | 0.109 | 0.36 | 0.72 |
| -heterogeneity | 0.011 | 0.505 | 0.02 | 0.98 |
| Common wildlife + 50% | -0.088 | 0.101 | -0.87 | 0.39 |
| -heterogeneity | 0.088 | 0.739 | 0.12 | 0.91 |
| End. Wildlife threatened | -0.057 | 0.124 | -0.46 | 0.65 |
| -heterogeneity | 1.063 | 0.324 | 3.28 | 0.00 |
| End. Wildlife common | -0.109 | 0.122 | -0.89 | 0.37 |
| -heterogeneity | 0.345 | 0.757 | 0.46 | 0.65 |
| **Lower future income x** | | | | |
| Common wildlife + 25% | -0.015 | 0.099 | -0.15 | 0.88 |
| -heterogeneity | 0.083 | 0.534 | 0.16 | 0.88 |
| Common wildlife + 50% | -0.079 | 0.118 | -0.67 | 0.50 |
| -heterogeneity | 0.857 | 0.319 | 2.69 | 0.01 |
| End. Wildlife threatened | -0.294 | 0.108 | -2.74 | 0.01 |
| -heterogeneity | 0.789 | 0.367 | 2.15 | 0.03 |
| End. Wildlife common | -0.252 | 0.113 | -2.24 | 0.03 |
| -heterogeneity | 1.277 | 0.380 | 3.36 | 0.00 |
| **Higher future income x** | | | | |
| Common wildlife + 25% | 0.126 | 0.093 | 1.36 | 0.17 |
| -heterogeneity | 0.016 | 0.359 | 0.05 | 0.96 |
| Common wildlife + 50% | 0.175 | 0.095 | 1.84 | 0.07 |
| -heterogeneity | 0.704 | 0.292 | 2.42 | 0.02 |
| End. Wildlife threatened | 0.280 | 0.093 | 3.00 | 0.00 |
| -heterogeneity | 0.530 | 0.374 | 1.42 | 0.16 |
| End. Wildlife common | 0.263 | 0.090 | 2.92 | 0.00 |
| -heterogeneity | 0.631 | 0.375 | 1.68 | 0.09 |

It is seen that all main-effect attributes have the expected sign. The main effects attributes crossed with current income level results in parameters indicating that high current income groups do not differ much from the average group. The low current income groups on the other hand do differ from the others, as their WTP is lower for the protection attributes in particular, but only slightly so for the access attributes.

Regarding expected changes in future income we see that, respondents who expect a lower future income state a lower WTP for increased populations of endangered species as well as general wildlife, but the latter not being significant. Conversely, the respondents expecting a higher future income tend to state a higher WTP for increased populations of endangered species as well as general wildlife, again the latter not being significant at the 95% level.

Note that most of the heterogeneity parameters are non-significant, but most notably not for the respondents stating a lower future income. This indicates that there is some variability in group expecting a lower future income, which have not been captured by the current split into current and future income.

In order to analyse further if expected changes in future income can have an influence we grouped respondents being students, which are likely to expect a higher future income, and also respondents close to retirement, defined as being above 58 years and not yet retired. Result for this analysis is shown below for a conditional logit model. It is seen that students do tend to state a higher WTP mainly for the wildlife attributes. The ones close to pension seems to take changes in future income less into account, and only for endangered wildlife is the coefficient significant.

**Table 3. Conditional logit parameter estimates for a model with income effects and grouping of students and almost retired respondents.**

| | | | | |
|---|---|---|---|---|
| Log likelihood | -8359.5 | | | |
| Likelihood ratio X2 | 2537.48 | | | |
| P>X2 | 0 | | | |
| PseudoR2 | 0.1318 | | | |
| | **Coefficient** | **Std.error** | **z** | **P> \|z\|** |
| ASC | 0.135 | 0.061 | 2.230 | 0.026 |
| Price | -0.135 | 0.004 | -37.740 | 0.000 |
| Red. access whole year | -0.424 | 0.076 | -5.590 | 0.000 |
| Red. access summer | -0.244 | 0.070 | -3.510 | 0.000 |
| Common wildlife + 25% | 0.600 | 0.069 | 8.760 | 0.000 |
| Common wildlife + 50% | 0.521 | 0.066 | 7.960 | 0.000 |
| End. Wildlife threatened | 1.054 | 0.076 | 13.960 | 0.000 |
| End. Wildlife common | 0.858 | 0.072 | 11.950 | 0.000 |
| **Low income x** | | | | |
| Red. access whole year | 0.283 | 0.115 | 2.470 | 0.013 |
| Red. access summer | 0.089 | 0.102 | 0.880 | 0.380 |
| Common wildlife + 25% | -0.447 | 0.093 | -4.790 | 0.000 |
| Common wildlife + 50% | -0.637 | 0.086 | -7.380 | 0.000 |
| End. Wildlife threatened | -0.536 | 0.104 | -5.130 | 0.000 |
| End. Wildlife common | -0.386 | 0.105 | -3.660 | 0.000 |
| **High income x** | | | | |
| Red. access whole year | -0.018 | 0.116 | -0.150 | 0.878 |
| Red. access summer | -0.007 | 0.102 | -0.070 | 0.943 |
| Common wildlife + 25% | 0.008 | 0.095 | 0.090 | 0.931 |
| Common wildlife + 50% | -0.089 | 0.087 | -1.030 | 0.303 |
| End. Wildlife threatened | -0.058 | 0.105 | -0.550 | 0.581 |
| End. Wildlife common | -0.129 | 0.106 | -1.220 | 0.223 |
| **Studying x** | | | | |
| Red. access whole year | -0.028 | 0.158 | -0.170 | 0.862 |
| Red. access summer | -0.064 | 0.145 | -0.440 | 0.658 |
| Common wildlife + 25% | 0.186 | 0.130 | 1.430 | 0.154 |
| Common wildlife + 50% | 0.350 | 0.122 | 2.860 | 0.004 |

| | | | | |
|---|---|---|---|---|
| End. Wildlife threatened | 0.516 | 0.152 | 3.390 | 0.001 |
| End. Wildlife common | 0.538 | 0.150 | 3.600 | 0.000 |
| **Near retirement x** | | | | |
| Red. access whole year | -0.167 | 0.161 | -1.030 | 0.301 |
| Red. access summer | 0.056 | 0.141 | 0.400 | 0.691 |
| Common wildlife + 25% | 0.169 | 0.129 | 1.310 | 0.189 |
| Common wildlife + 50% | 0.122 | 0.119 | 1.020 | 0.307 |
| End. Wildlife threatened | -0.107 | 0.145 | -0.730 | 0.463 |
| End. Wildlife common | -0.483 | 0.147 | -3.280 | 0.001 |

## 4. Discussion

The present study addresses the identification of income effects on WTP-measures in environmental valuation studies. We have formulated the hypothesis that respondents' stated WTP for environmental goods is based not only on their current income levels, but also on their expectations concerning their future household income. This hypothesis has found strong support in the results reported here. The implications of this are quite strong. First, it suggests that the widespread difficulties in identifying a significant and positive income may simply reflect that the income measure applied in such tests, i.e. current income levels of the individuals or households addressed, is simply a too poor representation of the income measure on which respondents base their answers. Secondly, the results raise the question of which income measure is to replace current income if better estimates of income effects are to be obtained. The current study has used a qualitative assessment of expectations of future income levels. This has the advantage of being un-provoking and easy to answer. Respondents may have difficulties in giving exact answers to this type of questions, and in fact may base their decisions on expectations as imprecise as the one suggested to them in this study. Nevertheless, future research should pursue the option of having respondents address their expected future income level in absolute or relative, quantitative measures. Thirdly, the role of wealth needs perhaps exploration too, as this also affects the consumption options over the life cycle. For example, the reason why we see little WTP-deviations for the group about to retire may be that even though this group faces decreases in annual income, they may wealth that compensates for this decrease and affects their WTP positively.

In the present study the cross-effect between the different attributes and current income groups is significant with the expected sign for some of the attributes. Most notably it is seen that WTP for the wildlife attributes is significantly lower for low income groups than for middle and high income groups, indicating that for these attributes WTP seems to increase by income but only until a certain level at which it stagnates. For the access attributes, the effect is not significant, indicating that access is less income dependent. This means that for the use-related attribute, access, there is hardly any income effect, thus the importance of this attribute is relatively larger among lower income groups than among higher groups as they state a significantly lower WTP for the wildlife preservation attributes. Opposite for the wildlife attributes, here WTP increases with income and more for the endangered species than for the common, i.e. more the less use-related the attribute. It is also worth noticing that relative to income, the high income group does not seem to gain more than poorer groups (expressed as WTP), thus relative to their income protection of wildlife and access to nature is relatively less important to them than to the rest of the population, and i.e. it is regressively distributed.

The future income effect is also seen to be highest and positive for the wildlife attributes, higher for the endangered than for the general wildlife, and not at all present for access. Again it indicates a regressive distribution, especially for the use related attribute. For future income effects we see that expected increases tend to be more important than expected decreases – a pattern which is mirrored in the analysis with students and almost retired respondents.

## 5. Concluding remarks

We formulated the hypothesis that respondents' stated WTP for environmental goods is based not only on their current income levels, but also on their expectations concerning their future household income. This hypothesis has found strong support in the results reported here, and the implications of this are strong. It suggests that the widespread difficulties in identifying a significant and positive income may simply reflect that the income measure applied in such tests has, i.e. current income levels of the individuals or households addressed, is simply a too poor representation of the income measure on which respondents base their answers.

The results furthermore raise the question of which income measure is to replace current income. This question is not addressed directly in this study, where a qualitative assessment of expectations of future income levels has been used. However, future research should pursue the option of having respondents address their expected future income level in absolute or relative, quantitative measures. In addition the role of wealth needs exploration too

Apart from these results, this study also carefully analyses the effects of current income and expected changes in future income on stated WTP for the different attributes. We find WTP to increase with income, but only until a certain income level and this effect is more pronounced for protection of endangered wildlife than general wildlife, which is again more pronounced than for access. This indicates that especially access is relatively more important to low-income groups. We also find future income to be relatively more important for stated WTP for the protection of wildlife attributes, but not for access. The effect is largest and positive if future income is expected to increase.

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# Contract design from a landowner perspective

**Working paper**
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## Abstract

There is a political goal in Denmark to increase the amount of forest from 12 % to 20-25 % of the land area and approximately 63 % of the land area is farmland which is mainly privately owned. Therefore, political goals with regard to afforestation cannot be satisfactorily reached on state owned areas alone and afforestation has been subsidized in Denmark since 1990. Due to private property rights and the possible conflict with public interest in nature, methods are needed to induce incentives for afforestation on private land. Contracts between the state and landowners are a common way to do this. Often monetary incentives are used as the primary way to heighten the acceptance rate of the contracts, however, little is known with regard to the effect of other attributes. This paper present a proposal of a planned study where we would like to investigate the effects of: main purpose of the afforestation, value of the option to denounce contract, size of afforested area and timing of the compensation.

Data will be gathered through a Choice Experiment investigation (CE). The CE method is chosen since it allows us to investigate both quantitative and qualitative attributes at various levels.

**Key words**: Contracts, afforestation, choice experiment, attributes, landowner, contract theory, adverse selection.

## Introduction

Afforestation is of increasing importance and can be related to multiple goals as ground water protection, enhancing biodiversity, carbon sink, recreational use etc. In Denmark it is a national goal to increase the forest area from approximately 12 % in 1990 to 20-25% within the next 80-100 years. This requires a yearly afforestation of 4-5,000 ha and from 1989-1998 the afforestation had been less than 1,800 ha/year (SNS, 2008a). Since 63 % of the land is farmland (Dansk Landbrug, 2007) mainly owned by private landowners a great deal of the afforestation has to take place on private land in order to reach the national goal.

Politically determined goals will, however, often be in conflict with the objectives of private landowners; e.g. the food prices at the moment pulls toward farming instead of afforestation. In most cases it will be necessary for the state to provide private landowners with incentives to reach the political goals concerning afforestation. It is important that the goals are reached through incentive providing schemes where landowners may choose a contract on a voluntary basis since the experience of being forced through regulations is known to greatly diminish private utility and joy of ownership (Horne, 2006). In Denmark contracts are a common used method to induce incentives for nature management on private land. Only 6% of the open land is designated as a zone where afforestation is wanted, 69 % where afforestation is possible (neutral areas) and 25 % where it is not wanted (Jørgensen, 2008). The applications have the last 3-4 years been equally distributed among the positive and neutral areas which mean that the density of applicants is much larger in the positive area. There have not been applicants for the entire subsidy pool the last 3-4 years (Jørgensen, 2008)

Often, the design of schemes and contractual relations for increasing nature management on private land are based on minor adjustments in the type of scheme previously used, combined with the planner's personal perspective on how it should be designed. In a planning context this can be referred to as "muddling through" (Lindblom, 1959). More knowledge is needed concerning landowners' preferences and trade-offs between contract attributes if afforestation policies should be optimized in the future.

The aim of this study is to investigate forest owners' preferences and trade-offs between different attributes in contracts for afforestation in order to improve the contractual relationship. We would like to investigate if the aim of the afforestation has an effect on the private utility of the landowner and thereby on the required compensation. Furthermore, we investigate the value of providing the landowner with an option to denounce the contract and the effect of the timing of the compensation. The effect of the size of the afforested area will also be analyzed.

The contractual relationship can be improved from both the perspective of the planner and the landowner. The planner would like to find data which reveal new contractible background variables and she would also like to gain a better understanding of the opportunity costs and the private utility the landowner experiences when signing a contract for afforestation. Moreover, she would like to know the trade-off the landowners make between different attributes in the contract. The landowner can benefit from an improved contract design that suits the landowners preferences and trade-offs better.

## Contract Theory

The relationship between the planner and the landowner can be analyzed as a principal-agent relationship. Adverse selection in relation to agriculture and forestry has traditionally been applied to situations where agents have different cost or production functions; however, we would like to analyze the contractual relationship in order to gain a better understanding on the opportunity costs and private utility the landowner experiences in order to make the contract design more efficient.

Moral hazard and adverse selection are the two main issues which are dealt with in principal-agent settings. Both are a result of asymmetric information where the landowner has private information before (adverse selection) or after (moral hazard) the contract is signed. Here the relationship between landowners and the planner is analyzed in relation to adverse selection, because landowners are expected to have different management objectives, opportunity costs and private utility and we would like to gain knowledge on these differences in order to improve the contract design. The knowledge will help minimizing the asymmetric information.

The landowners' objectives will resemble the objectives of the planner to a greater or smaller extent and therefore some owners are expected to require smaller amounts of compensation compared with other owners. However, besides this we expect to find a trade-off between the levels of other attributes in the contract. Once this is known it can be used to further improve the efficiency and acceptance of contracts. The first studies to address the problems of adverse selection were Akerlof (1970) and Rotschild and Stiglitz (1976). Adverse selection issues are well known today and have been dealt with in modern textbooks of contract theory (Bolton and Dewatripont, 2005). Adverse selection analysis has been applied to forestry as a means for governments to improve market transparency and efficiency in forest certification (Rametsteiner, 2001). Furthermore, adverse selection has been applied to the pricing of irrigation water in relation to farmers who have heterogeneous production functions (Smith and Tsur, 1997). To our knowledge adverse selection has not previously been applied as a tool in the analysis of contractible background variables, contract attributes and variations in management objectives among landowners in relation to contracts for afforestation.

## Method

The aim of the study is to investigate landowners' preferences for different attributes in the contract. In order to be able to generalize and to develop guidelines to improve contract design in Denmark it is useful with a representative sample of landowners. The Choice Experiment (CE) investigation will be conducted as an e-mail survey and will be sent to a random selection of Danish landowners.

**The Choice Experiments method**

The CE method is based on probabilistic choice models which rely on random utility theory. The utility of each alternative consists of the sum of systematic and error components. The systematic component, V, is a vector of observable individual and alternative specific attributes and the error component consists of all impacts and factors affecting the choice which are not observable by the researcher (Louviere et. al., 2000). The theory states that an individual will choose an alternative *i* from a specific choice set, $C_n$, given the indirect utility of *i* is greater than the indirect utility of any other choice *j*. This means that

$$U_{in} > U_{jn} \Rightarrow V_{in} + \varepsilon_{in} > V_{jn} + \varepsilon_{jn} \quad \forall j \neq i; i, j \in C_n$$

Random utility theory states the probability by which an alternative is chosen given the systematic and error components. This means that the probability that an individual, *n,* chooses alternative *i* is the same as the probability that the utility of alternative *i* is greater than the utility of any other alternative of the choice set, which means

$$P(i) = P(V_{in} + \varepsilon_{in} > V_{jn} + \varepsilon_{jn}) \quad \forall j \neq i; i, j \in C_n$$

(Horne, 2006; Adamowicz et. al., 1997; Adamowicz et. al.,1998).

The CE method has been applied to a large number of investigations on valuation of non-marketed goods and recreational demand in relation to forestry in recent years (Hanley et. al., 2002; Boxall et. al., 1996; Biénabe & Hearne, 2006). However, so far only few investigations have been made on landowners' preferences with regard to contracts for nature protection or afforestation.

Choice experiments have been used to investigate landowners' attitude towards the optimal (perceived) population of moose in Finland (Horne & Petäjistö, 2003). Furthermore, the method has been used to assess Hungarian farmers' valuation of agrobiodiversity on small farms (Birol, Smale and Gyovai, 2006). Horne (2006) has used CE to investigate Finnish forest owners' preferences and acceptability of contracts, however, only the welfare of forest owners is considered in the investigation.

By using the CE method it is possible to combine qualitative and quantitative attributes which is useful in this context where levels of compensation are combined with, among other things, aims of afforestation.

A common problem in stated preference methods like CE is to make people answer truthfully. In this situation, where we ask landowners about the relation between compensation and various attribute levels, it is likely that they set the compensation higher than what they would actually be willing to accept, if they believe it might raise the compensation in future subsidy schemes. However, CE is still believed to be the most appropriate stated preference method since it makes the respondent compare two alternatives with different attribute levels against each other. The method provides us with the trade-offs between attributes over a broad spectrum of levels and these trade-offs will be relevant despite some degree of overstatement with regard to compensation. Nevertheless, this should of course be kept in mind when analyzing data.

**The choice of respondents**

The respondents are chosen among the group of landowners who have the option to afforestate. This can be both forest owners and farmers (together defined as landowners). In Denmark local authorities have divided the land area into three types of afforestation zones; positive zones where afforestation is wanted, negative zones where afforestation is not wanted and neutral zones where it is possible (SNS, 2008b). The landowners are picked from the positive and neutral zones. Owners with all their land in areas where afforestation should be avoided (negative areas) are excluded from the sample.

It is interesting to have both respondents who already have forest areas and consider themselves as primarily forest owners and landowners who consider themselves primarily farmers since there might be a difference in their willingness to accept a contract for afforestation.

In Denmark 62.1% of forest owners consider themselves first and foremost as farmers and 26.1% consider themselves 'leisure time' forest owners (Boon, 2003). The overlap between the two groups is another argument which makes it preferable to focus on the landowners who live in afforestation areas rather than either forest owners or farmers.

## The questionnaire

**The introductory text and the afforestation scenario**

The CE questionnaire includes an *introductory text* which aims at establishing the right setting and context for the owner before he/she answers the questionnaire, such as explaining briefly why afforestation is important. The aims of the survey (such as gaining knowledge on what landowners' find important in relation to afforestation contracts) will be explained. Furthermore, it will be pointed out to the owners that the answers will be kept confidential and specific answers and statements will never be linked to the individual. A common problem regarding the background variables is that people often refuse to state their income level. Therefore the introductory text will explain that the income level is necessary because the amount of payment/compensation needed concerning a specific contract is likely to vary with the income level. Afterwards follows an explanation of the attributes and attribute levels. In order to eliminate the effect of each owner reflecting on whether or not to afforestate a specific area where we do not know the characteristics and opportunity costs, we define the afforestation scenario so this will be common for all respondents.

The *afforestation scenario* will include information on size of area, establishment costs, and level of control. The afforestation area we characterize is arable land with wheat production and the average contribution will be stated. The expected establishment costs of the forest will be 30,000 DKK/hectare. The establishment of a new afforestation area can normally be complete within approximately 8 years and therefore the area will be checked after approximately 8 years in order to make sure that the contract is fulfilled. Moreover, it is stated what the expected yield of an established forest is.

The landowner will then be asked to choose the preferred alternative in the following choice sets. The forest owner should always have the option to choose neither of the alternatives (choose status quo) and, even though the status quo choice is shown as a box in the questionnaire, the option of refusing both alternatives will be emphasized in the introduction.

**Background variables**

The purpose of the background variables is to reveal information on how the relation between afforestation and compensation varies with characteristics of the owner and the land holding. Background variables are directly observable or accessible for the planner. This makes it possible to use the knowledge to develop new contractual variables and to gain knowledge about types of landowners in order to improve marketing.

**Table 1** The background variables in the questionnaire and the possible use of each of them. X: can be used. %: cannot be used. ?: Maybe.

| | | Contracts | Marketing |
|---|---|---|---|
| **Landowner characteristics** | Age | ? (%) | X |
| | Gender | % | X |
| | Level of Education | % | X |
| | Income | ? | X |
| | Duration of ownership | ? | X |
| | The primary source of income | ? | X |
| | Full time / part time | ? (X) | X |
| **Facts about land holding** | Area of forest and farmland and total | X | X |
| | Types of farm (animals or crops) | ? | X |
| | Zip code | X | X |

From society's perspective it will not be acceptable to use all the background variables we gather data on directly in contracts. For example, it would not be acceptable to offer differentiated compensation based on gender or level of education of the landowner even though it theoretically could be optimal to do so. Other variables, such as what is the main source of income or location of the land (zip code), might be contractible if they reveal significant differences in e.g. opportunity costs. If they can be included directly in the contract it can reduce the problem of adverse selection. An example is that existing Danish subsidy schemes for forest consultancy services use forest area as a contractible variable and differentiate the subsidy based on area.

The variables which are not socially acceptable to contract on have been included because the information they can bring forth may be useful in other ways. For example, if the planner knows that age or gender has a significant effect on the willingness to accept a specific contract, she can use this information to evaluate whether or not it is possible to reach her goal based on the proposed contract or if she has to make an extraordinary effort to get specific groups to participate as well. This could for example be through campaigns and information material which are targeted specific groups. All the 'marketing' attributes in table 1 can be used to improve campaigns.

Furthermore, the owner is asked questions concerning his objectives for owning the land and the importance of biodiversity and landscape values etc. He is asked how market prices influence his decision making, if he is concerned about water quality or biodiversity, if he has a private well, questions about if he would like to improve recreational options in the local area, if somebody else helps him make decisions, if he knows if there exist positive/neutral/negative areas for afforestation on his land, if he lives near to his land, if he has any previous experiences with contracts for different environmental goods etc. These questions are aimed at linking this investigation to previous studies of landowners (Boon, 2003) and to reveal information on possible explanations of the stated trade-offs.

### The attributes

**Table 2** Attributes to be used in the questionnaire and the different levels of each attribute.

| Attributes | Levels of attributes |
|---|---|
| Aim of afforestation | Recreation<br>Ground water protection<br>Carbon sink<br>Biodiversity |
| Size of area affected | 5 hectare<br>20 hectare<br>50 hectare |
| Option of denouncing the contract | Binding contract<br>Option of denouncing within 5 years<br>Option of denouncing within 10 years |
| Timing of payment | All compensation now<br>Half of the compensation now and half in year 8<br>All compensation in year 8 |
| Compensation | 10,000 DKK/ha<br>15,000 DKK/ha<br>20,000 DKK/ha<br>25,000 DKK/ha |

### Aim of afforestation

We investigate four aims of afforestation; recreation (to benefit people's leisure time activities in forests), groundwater protection, carbon sink (to help avoid global climate change) and biodiversity. These are all benefits of afforestation mentioned by The Danish Forest and Nature Agency in the Danish National Forest Programme (SNS, 2002). They are all public goods which are usually not marketed. Timber production is also mentioned by the

Danish Forest and Nature Agency but is not included since it is a marketed good.

The aim of the afforestation could have an effect on forest owners' willingness to accept a contract (and compensation) since they may have different preferences for the proposed aims. Owners may have different objective functions with regard to the scope of afforestation and perhaps experience private utility from creating a specific public good. Therefore, we would like to investigate if they experience different levels of utility depending on the main aim of the forest protection. So even if the opportunity cost of a specific contract is the same, the owners' preferences may vary if they for example believe that protection of water resources is a very important goal whereas afforestation for recreational purposes may be less important or conflicting with utility maximization. Another example is if a landowner uses the area for hunting, he/she might want to limit public access and thereby reject a contract for afforestation if the purpose is recreation.

**Size of area affected**

It is expected that the size of the area affected makes a difference to the landowner. A farmer who accepts to make afforestation on all his/her land is no longer a farmer and it is unlikely that he/she will accept this change since it causes a change in identity. An area can probably be too small as well making it unprofitable to spend time applying for the subsidy. The Danish Forestry and Nature Agency prioritize applications with an area above 10 ha and due to this it is interesting to investigate both areas below and above this limit (SNS, 2008c).

**Option of denouncing the contract**

Landowners are used to have all decision power and a loss of authority is expected to create a need for compensation. Since long term commitment and uncertainty with regard to market fluctuations are expected to be important factors when landowners choose a contract for afforestation, we investigate the value of having an option to denounce the contract within 5 or 10 years. If the landowner decides to denounce the contract he/she has to pay the subsidy back to the state (with a specified interest rate). However, the landowner will then be free to return the area to arable land. This will for example give the landowner the option to denounce the contract if the market for an alternative production suddenly improves a great deal. Since the landowner is used to production on a yearly basis it is interesting to investigate if the option to denounce is valuable for him/her. A binding contract means that the area will be forest reserve from the establishment; if the landowner has the option to denounce within 5 or 10 years, the area will become forest reserve after this period if the owner does not denounce the contract before.

The current subsidy scheme does have an option to denounce the contract if the landowner within the first two years do not use the subsidy or do not plant trees. If he/she does it is no longer possible to return to farmland. Before 2004 it was possible to remove the forest and pay back the subsidy with rents (Jørgensen, 2008).

In the long run the planner is interested in subsidizing areas which become forest reserve, however, giving landowners and option to denounce the contract within a number of years may lead to more afforested areas in the long run as well, if the option is valuable for landowners and they would otherwise decline the contract. Leaving the authority to the agent in decisions of his concern is in theory said to increase the effort level or the agents (landowners) acceptance of the contract (Aghion & Tirole, 1997).

**Timing of payment**

We use this attribute to investigate to what extent the timing of the payment affects the landowner's decision to accept or decline the contract. The current subsidy scheme for afforestation offers more than half of the compensation when the contractual relationship is established and the rest after maximum 8 years (if planted) or 12 years (if seeding) when the new forest area is successfully established (SNS, 2008c). We investigate the current procedure and the effect of delaying the compensation to year 8 or, alternatively, paying the landowner all of the compensation when the afforestation is established in year 1.

When delaying the payment there is a trade-off between inducing incentive to choose high effort and exposing the agent (landowner) to risk (Macho-Stadler & Pérez-Castrillo, 2001). The state has an interest in delaying the compensation to year 8 and combines it with a control visit of the successful establishment of the forest. This is assumed to minimize the problem of moral hazard since the landowner has an incentive to choose a high effort level in order to improve the probability of success. This exposes the landowner to risk since it is not certain that he will get all the compensation if the afforestation is not successful. The landowner is expected to be risk-averse and due to this it will be costly to expose him to risk. The state is considered to be risk neutral because of the size and theory tells that the state should take all the risk. The aim of investigating the timing of payment is to gain knowledge which can help the planner designing a contract with an appropriate balance between incentives and risk. The landowner will benefit from a contract design which suits his risk aversion better.

**Compensation**
Compensation is the amount of DKK the forest owner will receive per hectare. The compensation will be paid according to the timing of payment stipulated in the contract. Moreover, compensation is an attribute which makes it possible to quantify the trade-offs between the other attributes which will be useful knowledge to improve contract design. The actual compensation in Danish afforestation schemes varies from 13,000 to 25,000 DKK/hectare with the highest level of compensation to plantation of broadleaves in positive areas and the lowest level for direct seeding in neutral areas (SNS, 2008c). We have chosen levels of compensation matching this frame and one with lower compensation level in order to investigate if it is possible to make people participate for less.

## Discussion
The aim of this paper is to investigate landowners' preferences and trade-offs between different attributes in contracts for afforestation in order to improve the contractual relationship.

A discussion is whether the results can be used to improve contract design about nature management in general or only in afforestation contracts. It is expected that four of the five attributes (size of area, option of denouncing the contract, timing of payment and compensation) are important in other cases as well. This implies that if the answers should not be useable in general it is because the respondents see afforestation as something completely different than other types of nature management contracts and thereby have other trade-offs. The 'aim of afforestation' attribute which cannot be used in a questionnaire regarding e.g. biodiversity conservation can help reveal some of these trade-offs in relation to different aims. This makes it possible to state if e.g. public access through recreational use is expensive for the planner relative to e.g. groundwater protection. This value can be applied to biodiversity conservation if e.g. the main aim is to protect endangered species it would be expensive to ask the landowner to establish pathways through the area as well.

The afforestation case can influence the answers because of the irreversible nature of afforestation and time horizon. The fact that the afforested area will be forest reserve may make the landowners hesitant to afforestation. The increase in the market price of food is expected to lead to a decrease in the interest in afforestation. This makes it particularly interesting to investigate the option of denouncing the contract to see what the value is of making it possible for the landowner to see how the market develops and then later on having the option to cancel the contract if it is preferable. Still, there are several reasons for afforestation mentioned in the 'aim of afforestation' attribute and it is interesting to see how landowners value these purposes combined with a market situation which pulls towards farming instead. The food prices might influence the answers in a negative way according to level of compensation seen from a planner's perspective. However, it may be possible to use the results to see which attributes have the strongest effect on the answers and thereby gain general knowledge about trade-offs.

## Concluding remarks

We expect this future study to provide a better understanding of the private benefit/cost side landowners face when deciding whether or not to accept a contract for afforestation on their land. This knowledge, which currently is private information for the landowners, can be used to improve the contractual design in contracts for afforestation so it reflects landowners' preferences. This can be beneficial for both state and landowners. Moreover, we expect to gain knowledge on whether or not the aim of the afforestation has an effect on the private benefits/costs which the landowner experiences. Furthermore, we expect the irreversible decision of establishing a forest reserve to be a great step for most landowners/farmers who are used to dealing with arable land with yearly crops. Therefore we would like to investigate how valuable the option of denouncing the contract within a certain number of years is for the landowner.

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# Multiple motives of family forest owners in their speech about forest-related decision-making

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## Abstract

Family forest ownership incorporates economic as well as several other motivations. While traditional rural livelihood has lost significance in the Nordic countries, multiple motives of forest owners have risen to the forefront of guiding owners' forest management behavior. At the same time, the requirements of international forest and environmental agreements force national policies to safeguard biodiversity and pay attention to many other ecosystem services more efficiently. The recent success of voluntary biodiversity protection schemes in Finnish family forests has raised the need for investigating further the emotional factors that affect forest owners' behavior and decision-making. The present paper assesses the values and attitudes beneath forest owners' speech about their decision-making. Semi-structured research interviews with 30 family forest owners from Finland were systematically examined from the perspectives of biodiversity and multiple use attitudes. The results show a broadness of multiple motives and their confounding with small-scale proactive protection of important values in holding level. The findings encourage policy-driven forest informing and holding-specific forest planning to consider the biodiversity-related values and goal frames that are present in owners' decision-making. From a broader view, forest informing is recommended to be developed as instrumental soft governance, along with efficient economic incentives.

**Keywords***:* family forests, forest informing, forest management planning, forest policy, goal frames, values

## Introduction

Current forest policies and management planning practices are challenged by two major driving forces. First, international agreements for biodiversity protection (e.g. Convention on Biological Diversity 2004) have set the framework for national efforts. Second, value diversification among citizens in general (Kangas & Niemeläinen 1996, Karppinen & Hänninen

2000) and among family forest owners in particular (Karppinen 1998, 2000) has made the view of multiple motives of forests more relevant.

As a consequence, the relationship between forest-policy-driven information delivery and forest-owner-driven planning service has been forced to find a new balance. Recent literature on forest planning (Kurttila & Hänninen 2005, Tikkanen & Kurttila 2007) indicates that this adaptation is yet in process. There is a recognized need to continue renewing forest policies and forestry practices in order to gratify the diverse values of forest owners in the urbanizing society.

Therefore the present development task is: How to reach policy objectives in an owner-centered way in non-industrial private forests? By the research contributing to the challenge above, it would be possible to devise argued, practically applicable recommendations for soft policy tools, e.g. for informing, planning, and communicative decision support.

**Orientation and research questions**

Throughout the past few decades, the values and objectives of family forest owners have been approached in numerous international papers aiming at improvements in private forestry policy tools. Since neither universal (Schwartz 1992) nor postmodern value theory (Inglehart 1971) has been judged as capable of grasping the special features of forest ownership, tailored conceptual frameworks have been constructed and used in empirical studies (c.f. Karppinen 2004).

Motivation has been the key element in the framework of Kurtz and Lewis (1981) in Missouri as well as in the one of Hugosson and Ingemarson (2004) in Sweden. As an alternative theoretical base, the four basic environmental attitudes defined by Pietarinen (1987) – utilism, humanism, mysticism, and primitivism – have been applied by Kuuluvainen et al. (1996) and Karppinen (1998, 2000) in Finland, as well as by Serbruyns and Luyssaert (2006) in Belgium.

The limitation of purely value-based owner typologies is their weak or at least controversial connection with actual behavior (Ní Dhubhaín et al. 2007). However, research on environmental education has provided some insights of the essential role of emotions and beliefs as determinants of real actions (Grob 1995, Pooley & O'Connor 2000). It would therefore be essential to integrate these aspects into value-based theories when developing them further.

Recent environmental psychology has already tried to combine values, motives, objectives, emotions, and behavior as a unified theory of goal frames (Lindenberg & Steg 2007). According to the theory, the currently active frame affects the actor's thinking, receiving of information, seeing the alternatives, and finally, the action. Two of the three introduced goal frames, hedonic and gain frames make the decision-maker to pursue short-term pleasure or intermediate-term utility, respectively. The third frame, normative goal frame, in turn, leads to striving for appropriate behavior that is conformable with the norms of the society and beneficial for the environment. From the perspective of the present study, the goal frame theory is relevant, because forest informing, management planning, and decision support practices may determine which goal frame becomes activated. Through the goal frame effect, the tone and the content of the communication may thus essentially affect forest owners' real actions.

This study analyzes family forest owners' speech about their decision-making from the perspective of multiple motives. The general aim is to assess the values and attitudes beneath the relatively open retrospective talked in an interview setting. More specifically, the aim is to investigate further the emotional forces that drive forest owners towards more environmentally friendly behavior.

Bio- and anthropocentric views as well as soft and hard values on forest (Pietarinen 1987) constitute the theory base, while the findings are interpreted through cognitive, affective (emotional), and behavioral components of attitude (Rosenberg & Hovland 1960) and discussed in the light of different goal frames (Lindenberg & Steg 2007).

## Data and Analysis

The data comprises semi-structured research interviews with 30 family forest owners from southern Finland, representing two demographically and economically different regions: Pirkanmaa (Tampere region) and North Carelia (Joensuu region). The interviewees were selected subjectively to cover a broad variety of owner and holding characteristics (age, gender, holding size, dwelling place, occupation). Details of the interviewed owners can be found in Hujala et al. (2007, p. 457).

The interview discussions, which lasted slightly over an hour on average, covered history of forest ownership, multiple use of forests, forestry-related decision-making, and experiences of forest planning and decision support. The interviews were conducted in August–September 2005 by one individual interviewer. From the perspective of the present study, it is noteworthy that biodiversity was not included in the themes: the related issues came up in the interview contexts through initiation of the interviewees themselves. Therefore the spoken biodiversity-related issues can be interpreted to have true relevance for the owners.

The transcripts were analyzed intensively, guided by the orientation and research questions described above. Using NVivo software designed for qualitative research (Richards 2002), a total of 341 extracts relating to multiple uses, forest experiences, biodiversity, nature protection etc. were made. These extracts were then classified into 59 categories providing a list of empirically observed phenomena. Of each interview, an owner profile was formulated and then used in condensing the results. The in-depth analysis was done by one researcher, while the meanings of the findings were jointly elaborated by all present authors.

# Results

### The broadness of motives

Multiple motives shaping the forest ownership were found. The occurrence of different motive categories among the interviewees is presented in Table 1. While economic income and silviculture appears as the most widely found motive category with 93 percent of interviewees, multiple and recreational use motives follow with the share of approximately two thirds of owners. Economic safety and legacy for children are also rather common motives, evidently decelerating the strength of immediate economic income motives. Aesthetics, i.e. beauty of forest, and sentimental values were as well notably present in the interviewees' speech.

All above mentioned motive categories can be counted as anthropocentric, either utilitarian or humanistic values, the speech about them representing the cognitive component of attitude. Contrarily, biodiversity (bottom line in Table 1) belongs to the ecocentric family of values. Though biodiversity *as such* was not identified as an essential driving force (only 3 owners out of 30 showed its intrinsic value), the multiple motives may lead, according to the interviewees' explanations, to owner-initiated, small-scale protection of important values and areas in holding level. This can be seen as the behavioral component of attitude. These initiatives aim at protection of several important values, but they may simultaneously safeguard biodiversity as well.

**Table 1.** Multiple motives interpreted from the interviewees' speech.

| Motive category | % of interviewees |
|---|---|
| Economic income and silviculture | 93 |
| Multiple use | 70 |
| Recreational use | 63 |
| Economic safety or deposit | 60 |
| Legacy/children | 50 |
| Aesthetics | 43 |
| Sentimental values | 20 |
| Biodiversity | 10 |

**Positive and negative biodiversity attitudes**

Both positive and negative attitudes towards biodiversity or related institutions can be interpreted as emotional reactions towards some meaningful incidents, representing thus the affective component of attitude. Positive attitudes seem to be coupled with a soft value associated with forest. In these situations, the owner considers his forest as a source of multiple benefits beyond purely economic ones and is ready for thinking trade-offs.

According to the owners, the positive attitude is strengthened when the high environmental value and/or the low economic value of the biodiversity object is shown or illustrated. If neither, offering compensations for economic loss opens the door for a more positive attitude.

Negative attitudes towards biodiversity are, in turn, originated from strong emotions, such as bad experiences of non-voluntary nature protection programs, worry of livelihood or identity (forest income dependent owners in particular), or fear of losing control over one's own property. All these categories associate with distrust or perception of illegitimacy towards forestry professionals or environmental administration.

The analysis also indicated that sentimental values may lead to either negative or positive views on biodiversity. Such values are coupled with deep emotions that are hardly manageable. An example of the consequences of sentimental values is a decisive refusal from harvestings on experientially important sites. On the contrary, sentimentally orientated owners may conduct "doubt harvestings" when some top-down nature protection intentions are assumed, to avoid losing control over property.

From the viewpoint of biodiversity and related consulting, symbolic values behind caring about the forest play an important role. Ownership as a trans-generational project (see also Törnqvist 1995, Lönnstedt 1997), link to the childhood residence, and intrinsic value of ownership are the main factors that make forest an object of multiple soft attitudes.

## Discussion

When evaluating the relevance of the present results, it should be taken into account that the interviewees do not constitute a representative sample of a population. The interviewed owners had ordered a forest management plan, which indicates that they were all more or less active owners. However, the sample was diverse in terms of background characteristics, which makes the results informative. Therefore the phenomena found can be judged as relevant in qualitative sense, but their mutual importance in quantitative sense can not be generalized based on this study.

The results relating to the multiple goals of owners as well as to the symbolic values are conformable with the earlier results by Lönnstedt (1997) and Tikkanen et al. (2006). The findings encourage the designers of forest policy-driven informing schemes and the developers of holding-specific forest planning to genuinely consider the biodiversity-related multiple values that are present in owners' decision-making. They can offer kind of a tailwind for the consultative communication pursuing biodiversity friendly behavior. Such consultation should fuel the hedonic goal frame by explaining how the suggested actions make the owners feel good.

The findings around negative and positive emotions, including sentimental values, indicate that feeling may be more important than knowledge when it comes to forestry behavior. The result is in line with the suggestion of Pooley and O'Connor (2000) but new as such in forestry field. Positive attitudes can be supported within the normative goal frame by explaining the societal regulations and environmental benefits with respect to the suggested action. The normative goal frame should however be fed with caution, since mitigating negative feelings may rather require the use of the gain goal frame.

The results emphasize the role of voluntary means for biodiversity protection in family forests. Offering compensations for economic loss seems reasonable in order to strengthen the positive and mitigate the negative attitudes towards biodiversity. This indicates that the recently developed biodiversity-related decision support methods (Kurttila et al. 2008) and opportunity cost calculation procedures (Kurttila et al. 2006) do have potential and should thus be further developed and adopted in practice. Those methods are conformable with the gain goal frame and are at best applicable in situations when the owner shows interest towards economic benefit and utility maximizing.

Based on the results above, it is hereby suggested that forest informing with multiple values should be developed as instrumental soft governance, along with efficient and legitimate economic incentives. Fueling of different goal frames in different situations could be a sound solution. Rather than sermons – as defined by Serbruyns & Luyssaert (2006) – such information delivery should approach consultation, which carefully takes advantage of the knowledge about owners' existing emotion-driven attitudes. Similar approach could initiate biodiversity-friendly behavior and increase commitment to forest plans as well. However, both the decision support services and the resulting management that focuses on multiple motives and biodiversity protection activities should be intensively subsidized.

## Conclusions and further research

In this study, family forest owners' multiple motives affecting their decisions as well as biodiversity-related attitudes were qualitatively examined. The idea of analyzing themes that were not included in the original interview guide proved reasonable. The analysis yielded both confirmation for earlier results and some new relevant perspectives.

However, the present data needs augmenting. In order to draw a more complete picture of family forest owners' multiple motives, two additional groups of owners should be investigated. First, those who have willfully ordered an ecology-based forest plan, and second, those owners who do not want to buy any of the present services.

To conclude, the development of forest planning calls for sophisticated and practically adoptable methods for comparing the consequences of alternative biodiversity protection contracts. These should be designed, experimented, reflected, and reported scientifically, and the communicative services should be delivered to the owners in a sound way.

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# Finnish family forest owners' retention tree management behaviour

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## Abstract

In Scandinavia a widely adopted biodiversity maintenance measure in managed forests is to leave retention trees to the clearcutting areas. A certain number of retention trees are left to the cutting area permanently as residual trees, which distinguishes them from shelterwood and seed trees. The aim is to increase the amount of large-diameter decayed wood in managed forest stands throughout their different development stages. However, there is evidence that some forest owners have removed the retention trees. The attitudes of forest owners in Finland towards biodiversity issues in managed forests and their knowledge and behavior concerning retention tree management were studied based on two surveys conducted in 2001 and 2006. In general, forest owners' attitudes were positive but their level of knowledge on biodiversity issues was moderately low. There were no significant change in forest owners´ attitudes and the level of knowledge between the two succeeding surveys. A sample of clearcutting areas was measured in order to find out if retention trees had been removed during a decade after the clear-cut. According the results some retention trees had been removed from every third of the inspected cutting areas. All the retention trees were harvested only from four percent of the areas. Received forestry extension and better knowledge on biodiversity issues decreased the likelihood to remove the retention trees.

**Keywords:** Biodiversity, forestry extension, forest management recommendations, non-industrial private forest owners, retention trees

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## 1 Introduction

The two principal instruments for safeguarding forest biodiversity are protection of the most valuable forest ecosystems through establishment of conservation areas and the management of forest stands in a way that takes biological diversity into account. Since the Rio Declaration in 1992, principles enhancing ecological sustainability have been widely adopted into forest management practices in Scandinavia. For example in Finland, the forest management recommendations, i.e. the guidelines for managing private forests, were amended first in 1994, again in 2001 and lastly in 2006. The Forest Act and the Nature Conservation Act were amended in 1996, and at the end of the year 2000 forest certification had been adopted throughout the private forests.

In practice, the effect of the changed goals and management principles in commercially managed forests has been twofold. First, certain small valuable habitats (like forests near streams, ponds, lakes or springs, small herb-rich forest patches and ravines and steeps) have to be set aside or managed so that their characteristics are preserved when forest stands are felled or otherwise managed. Second, certain structural characteristics have to be maintained when forests are regenerated. Among these characteristics, the most important are retention trees.

In regeneration cuttings a certain number of retention trees are left as permanent residual trees, which distinguishes them from shelterwood or seed-trees (Vanha-Majamaa and Jalonen 2001). The aim is to increase the amount of large-diameter decayed wood in managed forest stands throughout their different development stages. More accurately, the objective is to i) lifeboat species and processes over the regeneration phase; ii) increase structural variation in the stand; and iii) enhance connectivity on a landscape level (Franklin et al. 1997, Vanha-Majamaa and Jalonen 2001). Therefore, in regeneration cuttings it is important to pay attention to diversity, amount, and temporal and spatial continuum of the retention trees that will in the future form important part of the stand's decayed wood (e.g. Siitonen 2001a, 2001b).

The amount of decayed wood produced by the retention trees is very small compared to the amount of decayed wood in unmanaged natural forests. The degree to which biodiversity really benefits from rather small amount of retention trees is still unclear (e.g. Siitonen 2001b, Vanha-Majamaa and Jalonen 2001). However, preliminary results of Siitonen et al. (2006) indicate that retention trees increase significantly diversity of species on regeneration areas but their number usually is too small to enhance endangered species. The studies concerning man-made high stumps indicate that they are valuable habitats for many saproxylic species but also felled wood is needed (Jonsell and Weslien 2002, Jonsel et al. 2003, Lindhe and Lidelöw 2004, Lindhe et al. 2004).

The living retention trees may have also negative impacts on managed forests. They may hamper regeneration and decrease the increment of new tree generation (Valkonen et al 2002), and increase the occurrence of forest pests (e.g. Martikainen et al. 2006). However, the recent studies indicate that large groups of retention trees may provide an alternative food source for pine weevils, and may consequently reduce the damages caused by pine weevils on pine seedlings (Pitkänen et al. 2008).

Both the criteria of the Finnish Forest Certification System (FFCS) and the current Finnish forest management recommendations include instructions on the amount, diversity and location of retention trees. The criterion of the FFCS demands that at least five retention trees should be left onto the cutting area, and the forest management recommendations give instructions for the number, placement and diversity of the retention trees. It should, however, be noted that a demand for retention trees is not included in the Finnish forest law. The existence of retention trees is based on forest owners' voluntary actions, therefore owners' attitudes towards and knowledge on retention trees and their ecological function are fundamental issues.

The amount and quality of retention trees left to cutting areas has been surveyed annually since 1995 by local forestry centres (for more details see Hänninen 2001, Talousmetsien... 2000). The monitoring results show that the volume and amount of retention trees has increased since 1998, and are today on the average 4.0 $m^3ha^{-1}$ and 12–14 stems $ha^{-1}$after the regeneration cutting (fig. 1). The value of the retention trees has been estimated to be about 150 euros per hectare (i.e. 3% of the net income of harvest), which means approximately 20 million euros annual investment for biodiversity enhancement (Siitonen and Ollikainen 2006). The amount of retention trees left on a regeneration area is, on the average, larger than the certification criterion demand. The quality of the retention trees has also developed positively: the proportion of regeneration areas where the quality of the retention trees has been estimated to be weak or moderate was 9% in 2006 compared to 32% in 1998 (Hänninen and Kurttila 2007).

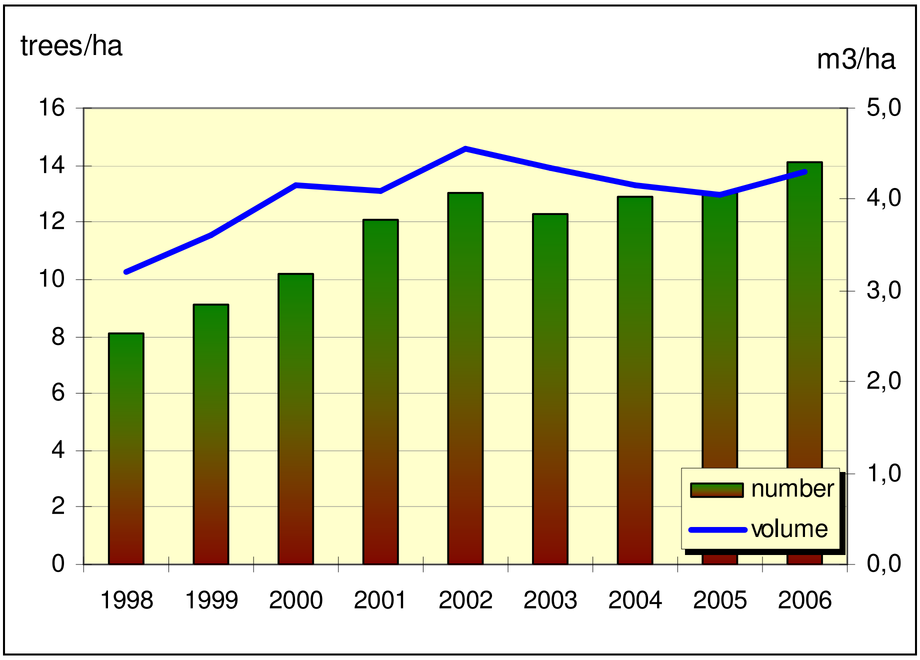

Figure 1. The amount (left axis) and volume (right axis) of retention trees in family forests during 1998–2006 (Hänninen and Kurttila 2007).

Unfortunately, there is evidence that some forest owners have removed the retention trees some years after the felling (Salomäki 2005), a phenomenon which has been noticed also in Sweden (Larsson and Elander 2004). In Finland, family forest owners self-actively carry out certain forest management operations, of which majority are pre-commercial treatments. For example, more than 60% of artificial regeneration, tending of seedling stands and improvements in juvenile stands and energy wood cuttings are carried out by family forest owners themselves (Koho et al. 2004, Karppinen and Hänninen 2006). While doing these treatments there is a risk that some landowners remove retention trees. The earlier studies concerning forest owners' knowledge on the retention tree management showed their understanding being rather poor in the year 2001 (Hänninen and Kurttila 2004, Kurttila and Hänninen 2005). Since then biodiversity issues have been emphasized in forestry extension.

The objective of this study is to find out the attitudes of Finnish family forest owners towards biodiversity conservation in commercially managed forests and their knowledge and behaviour concerning retention tree management. The effect of forestry extension is also evaluated.

## 2 Materials and methods

### 2.1 The data

The data consist of two surveys – in 2001 and 2006 –, and two forest inventory in 1998–99 and 2006 (fig. 2). The basic population of the study was private forest owners who had carried out cuttings between years 1996 and 1998. The forestry centres took a sample among the cutting areas of these landowners according to more detailed criteria and inspected the quality of the cutting areas during years 1998 or 1999. This inventory data were supplemented with mail inquiry during spring 2001. The questionnaire form was sent to the 1,048 family forest owners, and the response rate was 55.8% and the usable data included 585 observations. The second survey in the beginning of the year 2006 was addressed only to those 537 owners of the original sample who had left retention trees to the clear-cutting area the response rate being 56.4%.

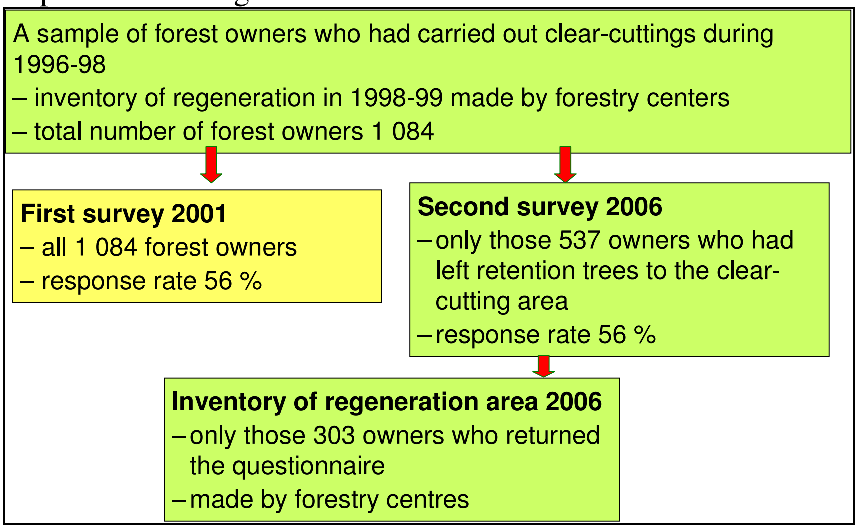


Figure 2. The structure of the data in the study.

In the mail questionnaire of the year 2001, 29 arguments concerning the rules and recommendations included in the Forest Act, official forest management recommendations and the certification criteria were presented to the forest owners. Ten arguments were related to retention tree management issues and only these arguments are examined in more detail in this study. In the questionnaire, the respondents were asked to decide, whether the presented arguments were true or false. In addition, "don't know" answer was possible. The arguments concerning the retention trees were based on official forest management recommendations (Luonnon-läheinen... 1994), forest certification criteria (Suomen metsäsertifiointi…

1999), and publications that relate to retention tree subjects (e.g. Säästöpuut 1998, Kotiharju and Niemelä 2000). In addition, the questionnaire included attitude statements concerning biodiversity conservation, the background characteristics of the respondents, their forest holding characteristics and some information concerning their forest management activities. The questionnaire of the year 2006 was similar than in 2001 but a bit shorter the emphasis being in the retention tree management.

The answers to ten arguments were coded so that correct answer gave one point and wrong and "don't know" answers gave zero points. The forest owners' knowledge concerning retention trees was calculated by summing these points. Based on this sum, the forest owners were then grouped into three groups: lowest quartile "poor knowledge" ($x_{25}$, the knowledge level that includes 25% of the respondents), highest quartile "good knowledge" ($x_{75}$ that includes 25 % of the forest owners having the best knowledge) and "moderate knowledge" (50% of the forest owners that were located between these two groups).

The regeneration areas were inventoried by local forest center professionals in 1998–99 and again in the summer of 2006. The diversity, number and volume of living and dead standing retention trees and the volume of lying logs were estimated in the both inventories. In the inventory of 2006, also the diversity, number and volume of retention trees felled in storms or removed from the regeneration area, and as an indicator for logging conditions, the distance to the nearest road and dwelling place or summer cottage were estimated.

### 2.2 Cautions concerning the data

Concerning the interpretation of the results some limitations of the data should be taken into account. Firstly, forest owners have had a relatively short time to become familiar with new rules and recommendations. Forest certification, particularly, was a new thing for family forest owners at the time when the first mail survey was carried out.

Secondly, all of the sample forest owners had made recently regeneration cuttings, which may cause that they based their retention tree knowledge on these practical examples in which logging contractors usually had selected the retention trees. Therefore, the landowners had not yet been forced to consider the ecological function of the retention trees.

Thirdly, the sample of forest owners is not a representative sample from Finnish family forest owners. The results of this study describe the knowledge of forest owners who, on the average, own larger forest holdings and have higher forest management activity than "regular forest owner" (for more details of the sample forest owners see Hänninen & Kurttila 2004). If the survey had been addressed to all forest owners the knowledge could have been poorer.

Lastly, the presented arguments must have been difficult particularly to those landowners who had managed their forests mainly with the help of forestry professionals (e.g. local forest management associations) or who had made a contract on management with a forest firm. However, the number of missing answers was very small which indicates that respondents had been careful when answering to arguments.

# 3 Results

## 3.1 Attitudes towards retention tree management

Forest owners' attitude towards retention tree management was positive in general. More than two thirds of forest owners agreed that it is important to leave some large retention trees to regeneration areas to enhance biodiversity (fig. 3). Only about one fifth didn't consider leaving retention trees to be necessary at all. Almost half of the forest owners regarded aspens as retention trees to be a threat to growing seedlings. More than half the forest owners would require compensation for leaving retention trees into regeneration area. In the survey 2001 forest owners' considered more often that scenery values are not strongly enough taken into account in forest management practices and that it is necessary to leave some large retention trees on the clear cutting area to enhance biodiversity than in the survey conducted five years later (2006).

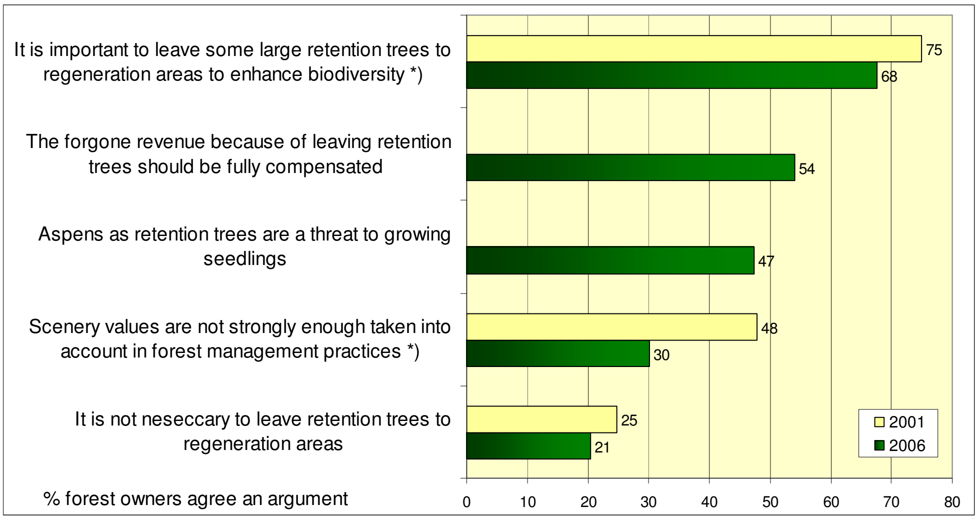


Figure 3. Forest owners’ attitudes toward retention tree management in 2001 and 2006 ($n_{2001}$=569–574, $n_{2006}$=297–301).

The forest owners who had received forestry extension agreed more often with the argument according to which leaving retention trees is important for biodiversity. This connection between forestry extension and attitudes was found in both surveys, but especially in the one conducted 2006.

All forest owners, whether they have received forestry extension or not, considered that the costs of retention tree management have to be taken into account when cuttings are planned. Consequently forest owners' motives in terms of biodiversity enhancement are not completely altruistic. The costs incurred by retention tree management are relatively small but that fact was apparently not often discussed at all with forest owners.

### 3.2 Forest owners level of knowledge on retention tree management

Forest owners' knowledge on retention tree management was examined in the questionnaire by presenting arguments which were related to the amount (questions 1 and 2), diversity (3 to 5), setting (6 and 7) and function (8 to 11) of retention trees. The respondents were asked to choose whether the argument was true or false or don't know. The results are presented in the table 1.

The forest owners knew very well the minimum number of retention trees (5 pcs $ha^{-1}$) demanded in the criteria of the FFCS and recommended in the forest management guidelines. The knowledge was very good also with respect of retention tree diversity recommendations. It was commonly known that snags and windfall trees should be left to the regeneration area, and that large aspens, willows and alders are valuable retention trees.

On the other hand, only about half of forest owners knew that decaying trees and other trees that are not economically important are valuable retention trees. The share of correct answers was significantly lower in the survey conducted 2001. In both surveys almost 60% of the respondents knew that the argument "Stand-alone spruces are recommended retention trees in regenerated spruce stands" was incorrect, whereas only about 40% knew that it is not recommended to leave retention trees evenly over the regeneration area.

The forest owners gave contradictory responses to the arguments related to ecological function of the retention trees. More than half of the forest owners knew that decayed wood is important also in young forests. However, 64% in 2001 and 51% in 2006 thought that retention trees should be removed during pre-commercial treatments or during first commercial thinning. Also the fact that soil preparation should not be carried out beneath the retention tree cluster was not widely known among forest owners (less than half of the respondents gave the correct answer).

Table 1. Forest owners' retention tree knowledge in 2006 and 2001 (the last one in parenthesis). The very well known (more than 60% of correct answers) arguments are shown in *italics*, and poorly known arguments (incorrect and don't know answers more than 50 %) are underlined. T/F means that an argument is true (T) or false (F); RECOMM refers to the forest management recommendation and CERTIF to the forest certification criterion indicating to what the instrument is based on.

| Arguments | T/F | Correct answer | Incorrect answer | Cannot say |
|---|---|---|---|---|
| *1. At least 5 retention trees per hectare should be left to the regeneration area (CERTIF)* | T | 67(63)* | 7(13) | 26(24) |
| 2. Only trees that were alive at the time of regeneration cutting are counted as retention trees (CERTIF) | T | –(47) | –(29) | –(24) |
| 3. Trees that have low economic value and decaying trees are valuable retention trees (RECOMM) | T | 52(45)* | 37(47) | 11(8) |
| *4. Snags and windfall trees should be left to the regeneration area (RECOMM)* | T | 78(79) | 14(16) | 8(5) |
| 5. Large aspens, willows and alders are valuable retention trees (RECOMM) | T | 58(60) | 29(29) | 13(11) |
| *6. Stand-alone spruces are recommended retention trees in regenerated spruce stands (RECOMM)* | F | 65(59)* | 25(28) | 11(13) |
| 7. Retention trees should be left evenly all over the regeneration area (RECOMM) | F | 43(37) | 43(51) | 14(12) |
| 8. Existence of decayed wood is not necessary for biodiversity in young forests (RECOMM) | F | 58(53) | 27(36) | 16(11) |
| 9. Retention trees should be removed during pre-commercial treatments of sapling stand or at least not later than during the first commercial thinning (RECOMM) | F | 35(27) | 51(64)* | 14(10) |
| 10. Under the retention tree group soil preparation is carried out similarly as elsewhere in the regeneration area (RECOMM) | F | 47(48) | 35(37) | 18(16) |
| 11. Retention trees felled in storms have to remove from regeneration area in order to avoid the risk of a forest damage (RECOMM) | F | 50(–) | 32(–) | 18(–) |

$n_{2001}$ = 567–579, $n_{2006}$=293–299.

– Not asked in 2001 or 2006. * The difference between 2001 and 2006 is statistically significant (t-test, 5%-risk level).

The forest owners were classified into three groups by calculating the number of correct answers: lowest quartile "poor knowledge" (the group includes 25% of the respondents, the ones who had the lowest level of knowledge), highest quartile "good knowledge" (group includes 25% of the forest owners, the ones having the highest level of knowledge) and "moderate knowledge" (the forest owners who were positioned between these two groups). On the average, all forest owners answered correctly to 5.1 arguments. For the forest owners with poor knowledge the number of correct answers was 2.1 on average, for owners with moderate knowledge 4.9 and for owners with good knowledge the average score was 8.1.

Forest owners were asked if they had received any kind of forestry guidance regarding biodiversity issues or especially retention tree management. The forest owners that had received forestry extension had significantly better knowledge on biodiversity issues than the others (table 2). The ones who had received information also knew the primary reasons for leaving retention trees more accurately. One third of all forest owners and 46% of the ones who had received advices concerning retention tree management were able to recognise the primary reasons to leave retention trees.

In the questionnaire of 2006 forest owners' were asked to list the most important reasons to leave retention trees (table 3). Many forest owners (43%) considered that the reason why retention trees should be left was to increase the number of natural seedlings on the regeneration area. Second most common reason was to leave retention trees for birds and other animals as nest trees. To increase the scenic values came in third. However, only 39% of the owners named the ecologically correct, i.e. primary reasons for leaving retention trees and 61% considered secondary reasons most important.

Table 2. The influence of forestry extension to forest owners level of knowledge on biodiversity issues in 2006.

| Forest owner has received information during 2001–2005... | Level of knowledge in biodiversity issues (number of correct answers) | |
|---|---|---|
| ...regarding biodiversity in general | Yes | 5.1* |
| | No | 4.2 |
| ...regarding retention tree management | Yes | 5.2* |
| | No | 4.1 |
| ...on both issues | Yes | 5.3* |
| | No | 4.2 |

* statistically significant, t-test, 5%-risk level, n=294–296

Table 3. Forest owners' opinion on the most important reasons to leave retention trees (in 2006).

| Reason to leave retention trees | % of forest owners | |
|---|---|---|
| Important for threatened species | 22 | |
| To produce decayed wood for micro-organisms | 19 | 39 |
| To diversify tree species structure and age-classes of the forest | 16 | *primary reasons* |
| Useful for natural regeneration | 43 | |
| Essential as nest trees for birds and other animals | 31 | 61 |
| To improve the aesthetic values of regeneration area | 23 | *secondary reasons* |
| Other reasons | 4 | |
| Total | - [1)] | 100 |

n= 313. [1)] The share of percent is over 100 because part of owners gave more than one reason.

### 3.3 Forest owners´ retention tree management behaviour

In the survey conducted in 2006 more than one fourth of forest owners (27 %) admitted that they had removed at least some of the retention trees from their regeneration areas. Two thirds of forest owners' said that they haven't removed retention trees and less than ten percent was not sure. According to the respondents most often they had removed wind falls (59%), living trees (slightly less than a third) and dead standing trees (about ten percent).

Forest owners who had removed retention trees were asked the reasons for that operation. The reasons were classified into three groups: economic, silvicultural and others. Almost half (46%) of those forest owners stated that retention trees were removed for economic reasons: valuable material has to be utilized for firewood or sawn timber. Every tenth forest owner had collected retention trees as a fuel. One third of forest owners said that they have removed the retention trees for silvicultural reasons. Most common argument was that the retention trees must be removed because the seedlings in the regeneration area are full grown. Forest owners' strongly supported the statement that one purpose of retention trees is to increase the number and quality of seedlings. These results indicate that the difference between retention trees and seed trees is not clear to the forest owners. Some (4%) of the forest owners considered that retention trees hinder the growth of the seedlings in the regeneration area and that is why they should be removed.

Table 4. The percentage of the regeneration areas on which the number or volume of retention trees has decreased more than 20% during the inventories 1998–99 and 2006.

| | Living retention trees | Large living retention trees ($d_{1,3}$>20cm) | Small living retention trees ($d_{1,3}$=10–20cm) | Dead retention trees (fallen trees, snags) |
|---|---|---|---|---|
| Decreased number | 25 | 29 | 18 | 33 |
| Decreased volume | 27 | 28 | 20 | 36 |

Less than one fourth of the forest owners mentioned other reasons for retention tree removal: most common of these reasons was that wind has fallen down the trees. This indicates that at least all of the forest owners haven't understood that dead and decaying retention trees are especially valuable for biodiversity.

According to the inventory at least some retention trees were removed from one third of the clear-cutting areas. However, all the retention trees were harvested only from 4% of the regeneration areas.

Sometimes it was difficult to observe the retention tree harvesting in the area. There were many uncertainties in the evaluation of the current number of retention trees left compared to the situation right after the clear-cut. Therefore the change was estimated by using a threshold value: if the number of retention trees had decreased more than 20% during the first inventory in 1998–99 and the second one in 2006 it was assumed that at least part of the retention trees have been harvested. By using the 20% limit assessment method it was found that the number of living retention trees was decreased on one fourth of the regeneration areas (table 4). Large diameter retention trees and wind falls or snags were both harvested on one third of the areas.

### 3.4 The factors affecting the likelihood to remove the retention trees

The characteristics of forest owners and forest holding didn't have effect to the likelihood to remove retention trees. Only differences observed were that the number of dead retention trees had decreased more often in the forest holdings owned by heirs and more seldom in the forest holdings larger than 100 hectares.

The location in vicinity of a dwelling place or a summer cottage decreased the likelihood to remove large retention trees. This can possibly be explained by willingness to retain the trees near inhabited areas because of scenery values. Ylikoski et al. (2004) have found the same result in their study concerning the probability for regeneration cuttings. As expected, location near by a road increased the likelihood to harvest retention trees.

Forestry extension seems to influence into forest owners' likelihood to remove the retention trees: the regeneration areas in which the number of retention trees had decreased were slightly less often owned by forest owners who had received forestry guidance, however, the difference was not statistically significant.

Higher level of knowledge decreased in general the likelihood to remove the retention trees. However, only in one case the difference between groups was statistically significant: forest owners in the group "good knowledge" had more rarely removed dead retention trees.

## 4 Discussion

Forest owners' attitude towards retention tree management was positive in general. More than two thirds of forest owners agreed that it is important to leave some large retention trees to regeneration areas to enhance biodiversity.

Forest owners answered correctly only to half of the arguments concerning retention trees. Forest owners' knowledge on biodiversity issues was good in respect of retention tree diversity and minimum number recommendations. Their knowledge on the ecological function of retention trees, instead, was quite poor. It is obvious that owners need more ecological justifications for retention tree management – the reasons why retention trees are valuable for biodiversity.

More than one fourth of forest owners said they had removed some retention trees, usually wind falls, from their regeneration areas. The results of the inventory verified that. At least some retention trees were removed from one third of the inspected clear-cutting areas; however, all the trees were harvested only from 4% of the areas.

Forest owners had removed retention trees for economic, silvicultural and other reasons. Economic reasons were the most common ones. Many forest owners considered that the reason why retention trees should be left was to increase the number of natural seedlings in the regeneration area. It seems obvious that landowners mix retention trees and seed trees used in natural regeneration. They also over-emphasize scenic impacts of the retention trees which could explain why so many fallen retention trees, which do not have scenic value, had been removed (on landowners' valuation of the retention tree attributes see Tönnes et al. 2004). If forest owners do not understand the ecological function of the retention trees or if they emphasize more the landscape function of the trees, there is a risk that they will remove the retention trees during later silvicultural operations. Naturally, larger amounts of fallen conifer retention trees may increase also a risk for forest damages, which can be one reason for caring forest owner to pile them up. Leskinen (2004) found out that part of forest owners eschew retention trees, think that they are waste of resources and are ready to use them, e.g. as firewood. Based of long-term forestry tradition of family forest owners this may even be considered as rational choice.

The characteristics of forest owners and forest holding didn't have much effect to the likelihood to remove retention trees. The location in vicinity of a dwelling place or a summer cottage decreased the likelihood to remove large retention trees. As expected, location near by a road increased the likelihood to harvest retention trees.

Forest owners' assumption on the costs of biodiversity enhancement varies largely. However, the value of the retention trees can vary a lot between regeneration areas. In principle, the retention trees can be trees that do not have commercial value at all. Alternatively, their value can be considerably high in some other cases. It is important that the loss of net income due to retention tree management should be clearly informed to forest owners, particularly in cases when more than the minimum recommended amount of retention trees is considered.

The effects of forestry extension were positive. The forest owners who had received forestry guidance with one way or other had more positive attitudes toward retention tree management, their level of knowledge was higher, and the likelihood to remove the retention trees was slightly lower but not statistically significant. The ones who had received information also knew the primary reasons for leaving retention trees more accurately. Despite of the extension services offered by forestry professionals during the five-year time period, forest owner's level of knowledge has improved only slightly. The attitudes toward retention trees were even worse than in the year 2001.

The forestry organizations that help and advice forest owners should, in addition to operational recommendations, also emphasize the ecological function of the retention trees. The amount and quality of retention trees, or more generally the biodiversity maintenance in private forests, may in practice depend more on the forest owners’ forest management goals than on the knowledge and strict implementation concerning the minimum requirements specified in instructions. The requirements do not take into account differences in owners’ forest management goals. The general development of forest management planning towards more goal oriented decision support, however, can alleviate this problem.

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# Parcelisation of family forests in Finland

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## Abstract

Forest holdings of sufficient size are one of the prerequisites for profitable forestry. This study will analyse the development in number of Finnish family forest holdings with affecting social, economic and political determinants. Firstly, a historical review is necessary. Secondly, a theoretical framework – based on economies of scale – with emphasis on progressive taxation effects is suggested. The major hypothesis to be tested in this study is that the major driver of parcelisation in Finland has taken place with respect to the population growth of the country.

In Finland, the partitioning of land has been deregulated gradually in time, it was almost completely deregulated in 1895 and then fully in 1916. After that, political and economic factors have been important parcellation drivers. Firstly, land reforms were instituted in order to liberalise tenant farms in the 1920s. Second of all, came the WWII resettlement of the Finnish population during the 1940s and which extended into the 1950s. Finally, there were great structural developments in agriculture, migration and urbanisation since the 1960s. These three changes have each accounted for an increase of some 100,000 family forest holdings.

The total number of independent and tenant holdings in Finland has been increasing for the last 250 years by an average of 8.6% with an increase in population of 10%. The increase in the number of holdings has been greater than that of the population in times when partitioning restrictions have been deregulated significantly, land reforms have been topical or property taxation high.

*Keywords: economies of scale, profitability, land policy, taxation policy*

## 1. Introduction

Forest parcelisation is one of the most important forest policy issues affecting both timber production and the profitability of forestry. In small holdings, recreation may become a more profitable main useage over timber production *per se*. Therefore, the actual cutting of timber, compared to allowable cut, may remain lower, the higher the share of small holdings is, in a country. For instance, in Sweden and Norway partitioning of arable and forest land is restricted in order to maintain economically viable agricultural and forest holdings. In Finland partitioning of land has been fully free from regulation since 1916. Restrictions upon partitioning have been in political discussion since then (e.g. Haataja 1935), but no amendments to hinder free partitioning have been made. One reason may be the relatively low population compared to the available land area in Finland.

In Finland, parcelisation has been studied by Ripatti (1996), who studied the probability of partitioning in a sample of holdings between two sequential points in time. His results indicated, for instance, that in the case where partitioning was made, it was three times more probable for jointly owned or non-agricultural holdings than for family owned or agricultural forest holdings, respectively. Parcelisation has also been an important issue in the United States, where the partitioning of land has had no restrictions. According to the literature review by Mehmood and Zhang (2001), the hypothesized causes of parcelisation can be divided into two groups: supply and demand. DeCoster (1998) finds that on the supply side the drivers are death, taxes and uncertainty. On the demand side the drivers are lifestyle and urbanization.

In Finland, historically speaking, forests have been used for hunting, agriculture, fuel, timber and tar production purposes. Commercial forestry within competitive timber markets has been in operation for no more than 100 years. Since the 1970's also, conservation has had an important role in forest land use. However, before commercial forestry, forestry as a land use form was not often an important part of land ownership policies, and the parcelisation of land progressed according to other land uses. Where other land uses did not maintain rural life, forests lost their value also.

The major objectives of this study are to find out:

1. What have been the major drivers of forest holding parcelisation in family forestry within a preliminary supply-demand framework?
2. How should forest holding parcelisation be controlled in Finland?

Firstly, a short historical background to Finnish land ownership development is presented. Secondly, advantages and disadvantages of scale in forestry are suggested as economic drivers for the partitioning of forest land. Thirdly, an econometric model based on the country's population is suggested as a method of analysis, revealing other factors in the development of the number of holdings. Lastly, findings from the econometric model are discussed against the backdrop of historical developments.

## 2. Parcellation drivers

### 2.1 History: Ownership of land

In the very long term, the major driver of parcelisation can be assumed as being determined by population, although in the short term, other factors usually dominate. This is also the major hypothesis to be tested in this study. Population, on the one hand, affects land demand, and on the other hand it affects the distribution of wealth, if policies concerning redistribution are employed in the country. To conclude, two general partly overlapping periods of population impact upon land parcelisation, and eight more precise periods of population impact on land parcelisation can be separated in Finland:

*1. Settlement (from prehistoric times until the 1950s)*
*2. Wealth redistribution (since the 1920's)*

*1. The occupation of land for settlement.* The first period of settlement traces the occupation of land by the Finns. In Finland, the population was first settled in the south-west. South-eastern parts of the country were settled from western Finland before 11th century. Middle and northern Finland were settled gradually, both from south-west and south-east (e.g. Orrman 2003a).

*2. Formation of villages.* The second period of settlement was based on family and population growth. Houses were inherited, resettled, sold, bought, and villages were gradually formed in south-western Finland. Elsewhere, the population was more scattered and single-house holdings were the most usual ones. Timber as such in that period was a rather invaluable product and forest ownership rights were mostly defined by their use as a hunting resource by settlers and villages (e.g. Jutikkala 1942). The total population of Finland at the end of 13th century was very small, maybe less than 50 000 (e.g. Orrman 2003b).

*3. Adoption of land regimes.* The third period of settlement was based on public intervention by the Catholic church and the Swedish crown, which gradually entered Finland in the 12-14th centuries (e.g. Orrman 2003b). Land regimes started to constrain partitioning and impact the housing organisation of holdings in order to maximise the tax revenues for the church and the king. This lead to densely built village formations in south-western Finland and to a cooperative agriculture due to the very narrow partitioning of cultivated lands. Although every household owned a certain well-defined part of cultivated land, borders were not drawn up in the relatively worthless forests, although borders between villages were defined. It is from this period that the so-called "common" forest ownership by villages originates. The church started to receive holdings into its ownership e.g. as donations. State formation was continued, and tax reliefs were introduced for owners of such holdings, which could provide services for church or state, mostly by arming a man and horse (e.g. Orrman 2003c).

*4. The impact of feudalism.* The fourth period of settlement was based on strengthening the centralised state and the reformation of the church after the break-up of the Kalmar Union in 1523. On one hand, since king Gustav Vasa's regime in 16th century, the crown had taken holdings which were the property of church. It had also taken abandoned holdings and holdings which could not pay taxes, into its ownership (e.g. Jutikkala 1942, 1983). In order to increase the population in border areas, such forest areas, which were not settled but used for hunting according to rights of enjoyment by villages and households, were also taken for the crown and opened for new settlement with temporary tax reliefs. On the other hand, the crown expanded the granting of land to persons, who had served the king in military and civil tasks and awarded them with rank or nobility. Furthermore, tax revenue collection was greatly privatised in the feudalistic manner.

In the available statistics, it is notable that the number of holdings was rather stable during the 17th century. During the period between 1550-1750 many noble estates were formed and ordinary holdings had to be given up in the redistribution of land properties. Tax reliefs for the holdings of noble families became inheritable and free from service for the state. However, state decisions (reductions) called off the privatised tax collection rights of manors during the second half of 17th century. Therefore, the impacts of feudalism remained restricted in Finland, and ordinary peasant holdings remained the most important landowners (e.g. Jutikkala 1983).

*5. The clarification of peasant property rights.* The fifth period of settlement was the launch pad for the modern holding structure in Finland. After a disastrous famine in 1697-99 and the Great Northern War (1700-1721), population and agricultural policies were reformed to support new land settlement policy (e.g. Ylikangas 2007). Adoption of the new policy required deregulation of holding partitioning (1747) and clarification regarding private forest ownership rights. After 1743, the formation of tenant farms was allowed also for peasant holdings and the expansion of the tenant system was begun. Land reforms were brought to a conclusion in the

*Great Partition* after 1757 and in the *Act of Union and Security* by Gustav III in 1789.

After the Finnish War (1808-1809), Finland became a part of the Russian Empire, but this did not have much affect on the formerly adopted population and land policies. However, the *New Partition* was instituted in 1848, because the results of the *Great Partition* were not good enough for the desired parcel formation. The importance of land tax with respect to state revenues was decreasing all the time. Therefore, the partitioning of holdings was deregulated every now and then, until it became almost free in 1895 (Vihola 2004).

*6. The settlement of independent Finns.* The sixth period of settlement was the first period of wealth redistribution. This was based on the policy that rural people should have a right to the land. The expansion of the timber industries as land owners was stopped by the Finnish parliament in 1915 by prohibiting their acquisition of family forest land. The partitioning of holdings was liberalised completely in 1916. After the declaration of independence at the end of 1917 and the civil war in winter and spring 1918, the liberalisation of tenant holdings became based on the ”Lex Pehkonen/Haataja” in 1918. Moreover, land was acquired for settlement according to the ”*Lex* Kallio” of 1922 and the ”*Lex* Pulkkinen” of 1925. After the *Winter War*, (1939-40) the act enabling the resettlement of evacuees was enforced, (1940) and after the *Continuation War* (1941-44) the act enabling land acquisition for the resettlement of evacuees from that war entered the statute books in 1945. Concerning economic policy, forest taxation had become property-based, site productivity taxation since the 1920's. Furthermore, separate property taxation was established, as well as inheritance and donation taxation.

*7. Building up the welfare state.* The second period of wealth redistribution started in the 1950s. The structural changes were accelerated at the end of 1960s. The importance of primary production was decreasing and urbanisation was increasing rapidly. Building up the Nordic welfare model required the expansion of tax revenues, which were collected by increasing the progressiveness of both income and property taxation. This meant that in the end, forests became the target. The peak in forestry taxation can be placed in the 1970s (Rutanen 1978, Sauli 1987). From the beginning of the 1980s, marginal tax rates were alleviated, especially for property taxation. In site productivity taxation, timber harvesting and silvicultural investments were encouraged (1980-2005) by adopting tax free areas after the final harvest.

*8. Modern polarisation of forest owners.* The third period of wealth redistribution started during the 1980s. First, the taxation of nominal profits from holding assignments was adopted in 1989. On the other hand, the transfers – of forest holdings lacking agriculture – to the next generation were gradually shifted, to be taxed now according to fairer values, instead of formerly employed taxation values. The average age of forest owners, as well as joint and urban ownership of forest holdings, started to increase. After 1993, forest incomes started to be taxed according to capital income, with fixed rates. Although this tax reform included a 13-year long transitional period for 1/3 of the holdings, it practically ended the progressive taxation of working forestry businesses. In 1990, agricultural forest owners were on average 55 years old and other forest owners 53 years old (Ihalainen 1992), whereas in 2003 agricultural forest owners had been 49 and other forest owners already 62 years old (Ripatti 2006).

## 2.2 Economies of scale

In theory, the supply of forest holdings by partitioning may be influenced by scale disadvantages in timber production. On the other side, demand for small holdings may be influenced by scale disadvantages in timber production, or the recreational (or conservation) user-value of forests exceeding the respective capital costs of the holding. Therefore, the economic impact of the holding size for the unit costs of timber production can be presented as a scale advantage, scale disadvantage or constant returns of scale (Figure 1). For simplicity, economies of scale connected to the forest owner are focused, and economies of scale connected to harvesting and silvicultural operations are ignored. Forestry costs are assumed to depend on:

a) rent of forest land,
b) wage costs of labour and forest owner entrepreneurship,
c) interest of capital (standing timber)
d) taxes levied by society.

The forest owner, as a forestry entrepreneur, may be assumed to create partly fixed and partly variable wage costs. For instance, a fixed wage may depend upon up-to-date forestry knowledge as well as upon regular follow-up on market information and variable wages with regard to the management of the holding area. Forest-owner related scale advantages are gained if the forest owner diverts his/her fixed entrepreneurship costs into a larger annual production of timber, which in the case of forestry usually requires a larger area of forest.

If land area or timber-quantity related progressive taxation costs exceeds scale advantages received from the decrease of unit costs in forest owner wages, unit cost of timber production will start to increase after a certain point in forest area, or annual timber production. This means scale disadvantage in timber production.

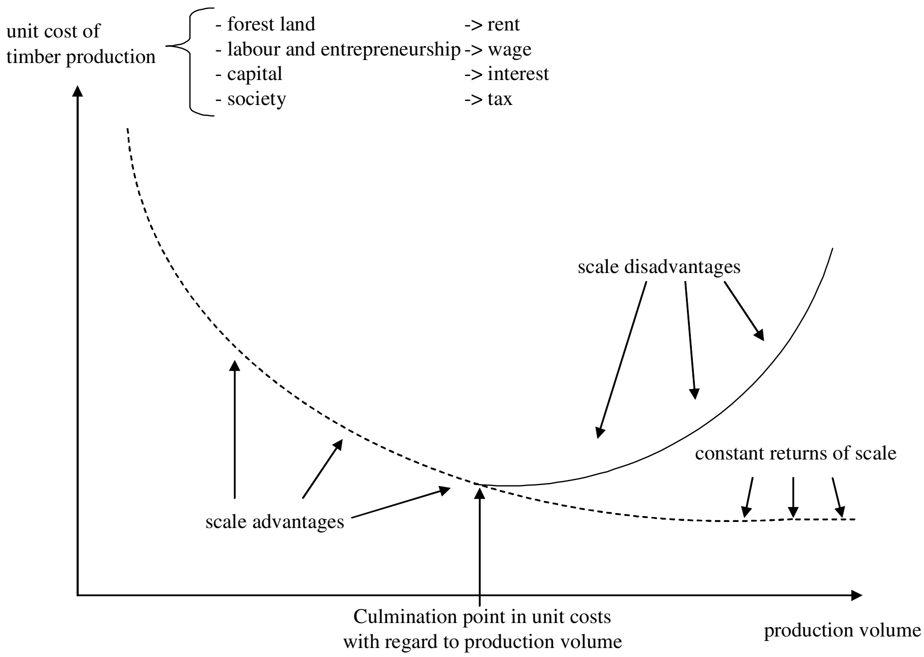


**Figure 1.** Economies of scale with regard to timber production volume (holding size).

Economies of scale may be applied also to property rights as opportunity costs. Land property rights on large holdings may become low e.g. due to land reforms favouring small holdings. If the value of timber and land are higher than the probable compensation in land reform, the opportunity costs i.e. scale disadvantage per cubic metre on large holdings will be high. As a consequence, large forestland owners may try to maintain their property rights by reducing the holding size and consequent land reform probability. This means sub-dividing the lands among the family/inheritors provided this is allowed during the land reforms.

Scale advantages may be gained in property rights, if the inheritance system favours a certain member of the family so that he/she may receive or buy the land in preference to other inheritors. For instance, the oldest son has previously been preferred, and is still preferred in some countries, in the inheritance system of agricultural and forestry land. In Finland, tax relief is available in inheritance and donation taxation, when a descendant continues agriculture and forestry as a single business. In this case the descendant usually buys the holding from the previous generation at a price which is under the market value of the holding.

## 3. Materials and method

In this study, population is considered as the major background factor in the supply of, and the demand for, forest holdings. The Swedish establishment of a system for population statistics *Tabellverket* of 1749, has meant, that Finland has had very good annual population statistics since the 1750s (Figure 2). Population is employed as an independent variable in the model to explain the development in number of forest holdings.

The most difficult task is to build a statistically consistent forest holding database for Finland. Definitions of holdings vary across time, and the existing statistics on holdings are not consistent. Today, there are statistics on management fee obligations for forest holdings, (taxation statistics). The taxation statistics include forest holdings, which have at least two hectares of forestland. Earlier, the minimum was one hectare. Forest holding statistics on management fee obligations were first collected for a full period between 1980-1987 (Ripatti and Reunala 1989). Since then, an almost complete database has been available, with improved quality on ownership details since 2001.

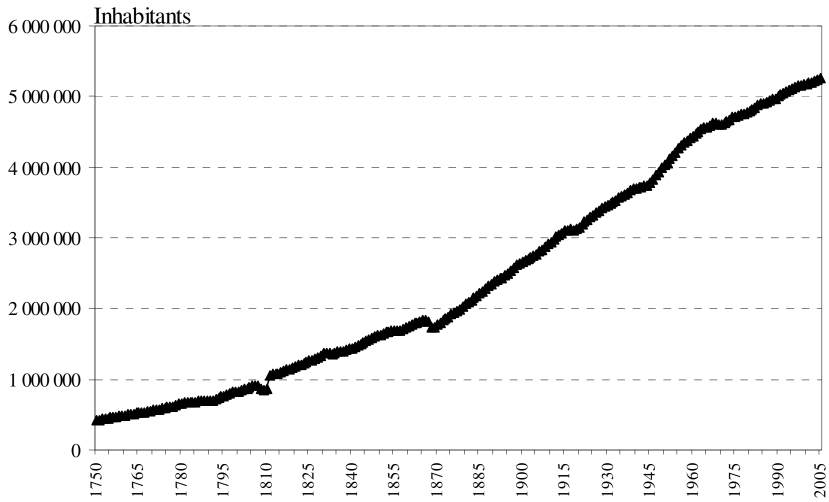


**Figure 2.** Population of Finland 1750-2005. Source: Statistics Finland.

Before 2001 there were also non-family forests included in the private forest taxation statistics, such as forests owned by municipalities and parishes. These holdings were mostly in the largest forest holding classes in the statistics. By using the information from the year 2001, data from previous years can be corrected by reducing the total number of holdings by 4,915, i.e. municipalities, parishes etc. Additionally, the statistics on family holdings which have a relief from the forest management fee, are not classified according to their holding size, but presented as a total number. These holdings with relief, are larger than average forest holdings as well. At the other end, small-holdings over the minimum acreage (today 2 ha), which are not obliged to pay the forest management fee, are neither classified according to any size-classes. Furthermore, the data is organised according to forest management associations, which have gone through a merging process during last few decades. This means that a merge of associations may decrease the number of holdings. The conclusion reached with the data is that the forest management fee statistics prevent virtually almost all kinds of family forestry size-class analyses since 1980.

Before the 1980s there are agricultural censuses (or equivalent) available for single years, 1901 (independent and tenant farms), 1930, 1945, 1959, and 1969. Before that, there is published data available for the years 1749 (independent and tenant farms), 1805 (independent and tenant farms), 1815 (independent and tenant farms), 1830 (only tenant farms), 1840 (only tenant farms), 1850 (only tenant farms), 1865 (only tenant farms), and 1875 (only independent farms). In this study it is assumed that, after 1930, there were no tenant farms left in Finland, and that they had become independent farms. This is not quite correct, but accurate enough for econometric modelling purposes.

Consistent time series of forest holdings are built by interpolating the periods between observations with constant annual changes in holding number. This method neglects possible fluctuations between observations. Although some exact changes are lost, these have probably taken place since 1918, where observations are available for under 15 year intervals

From the constructed time series it can be seen that the number of independent holdings increased between 1749 and 1815 relatively quickly. The pace slowed down remarkably until the 1880s. The 20th century has been a time of very rapid increases in the number of independent forest holdings. The periods between 1918-45, 1945-70 and 1970-2005 have each accounted for an increase of some 100,000 independent forest holdings. This means that the present situation totals some 300,000 independent family forest holdings more than in the beginning of 20th century (Figure 3).

The number of tenant holdings started to grow from some 4,000 farms in 1750 relatively steadily until the end of 19th century. From the end of 19th century the number of tenant farms started to decrease slowly, and after Finnish independence (1917) and civil war (1918), the liberalisation of tenant farms was carried out as a matter of national policy. Most of the tenant farms became independent agricultural holdings by the beginning of the 1930s.

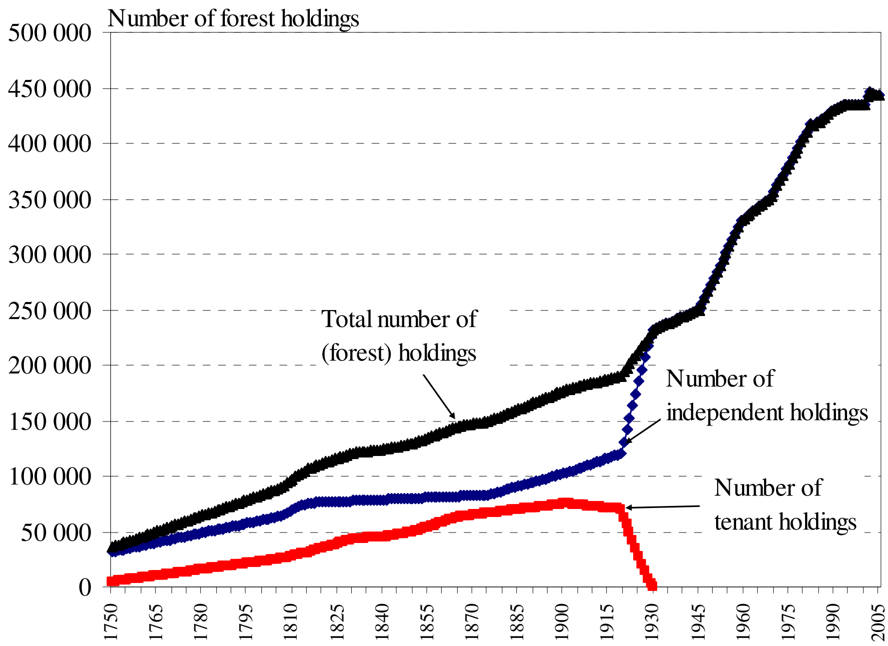


**Figure 3.** The number of forest holdings in Finland 1750-2005. Interpolated time series. Sources of data points: Jutikkala (1942), Rasila (2003), Ripatti & Reunala (1989), Ripatti (1996), Agricultural censuses and taxation statistics published in Finnish statistical yearbooks of forestry (various years) and Tapio's annual statistics (various years).

In statistical modelling, the simple *OLS-method* is employed, where population is used as the independent variable, and the number of forest holdings is used as the dependent variable. Natural logarithmic transformation is made for both variables in order to receive the elasticity interpretation between the population and number of forest holdings. In order to receive consistent results, the total number of forest holdings i.e. the sum of independent and tenant holdings, is used as the dependent variable.

Because both time series are growing and strongly autocorrelated, this results in poor diagnostics in the *OLS* modelling. However, if the causality is assumed to exist only in the long term between population and number of forest holdings, received elasticities can be used as such. Poor *OLS* diagnostics could be avoided, if there were time series of other affecting short term variables, at least slope and level dummies. Also taking differences of growing time series could result in stationarity of residuals, but in this case the most interesting long term causality would be lost. Because short term variables are not available exactly and the time series are over 250 years long, poor diagnostics of the model is ignored, and the received elasticity is used as if it was an efficient solution. Instead of constructing lacking variables, an interpretation of residuals with previously described history and theory, is employed.

## 4. Results with an interpretation for the 1970s

Compared to the country's population, the total number of independent and tenant holdings in Finland has been surprisingly steady for 250 years, varying in time between 6 and 11 percent of the population. The first relatively steady growth in percentage between 1750-1790 was from 8.6% to 10.5%. Then the share decreased until 1917 falling to 6.1%. From 1918 the growth was again relatively steady until 1980 up to 8.6% of the population. Since then the percentage share has been almost unchanged and in 2005 it was about 8.4%.

When *OLS-method* is employed, the elasticity interpretation indicates that in a very long period an increase in population by 10% increases the number of holdings by 8.6% (Table 1). As expected the model's diagnostic, especially with regard to autocorrelation, is very poor.

**Table 1.** The model for number of forest holdings with diagnostics.

Dependent Variable: TOTALHOLDINGS
Method: Least Squares
Sample: 1750 2005
Included observations: 256
TOTALHOLDINGS = C(1)+C(2)*POPULATION

| | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C(1) = Constant | -0.451247 | 0.136047 | -3.316837 | 0.0010 |
| C(2) = Elasticity | 0.857428 | 0.009398 | 91.23632 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | 0.970390 | Mean dependent var | 11.94435 |
| Adjusted R-squared | 0.970273 | S.D. dependent var | 0.657928 |
| S.E. of regression | 0.113437 | Akaike info criterion | -1.507362 |
| Sum squared resid | 3.268443 | Schwarz criterion | -1.479665 |
| Log likelihood | 194.9423 | Durbin-Watson stat | 0.013138 |

Next, residuals of the *OLS-model* are interpreted. Increasing series of the residuals indicate that the number of forest holdings are increasing faster than the model predicts, and decreasing series mean slower increase, respectively. When the series of residuals are flat, the elasticity is as the model predicts (8.6%). If the series of residuals are increasing or decreasing, the magnitude of the elasticity is dependent upon the period (Figure 4).

The first increasing series of residuals since 1750 were seen after allowing the establishment of tenant farms for peasant holdings in 1743 and an extension of partitioning possibilities with regard to holdings in 1747. The *Great Partition* was started in 1757 (Jutikkala 1942). However, new levels of effective partitioning restrictions seem to be met around 1790. After that there was a period of some 20 years during which the number of holdings increased approximately within the elasticity received from the *OLS-model*. The first residual peak is due to the Finnish War 1808-09, and it is because of a decrease in population. From about 1815 until about 1850 partitioning restrictions upon holdings were effective. For instance, in 1852 partitioning restrictions were deregulated relatively speaking, to a large extent, and amendments were made again in 1864 and 1883. From 1850 until the years of great famine (1866-68) the number of holdings was increasing according to the model. From 1870 until 1917 partitioning restrictions upon holdings were again effective and the number of holdings increased very slowly, although partitioning was almost fully deregulated from 1895.

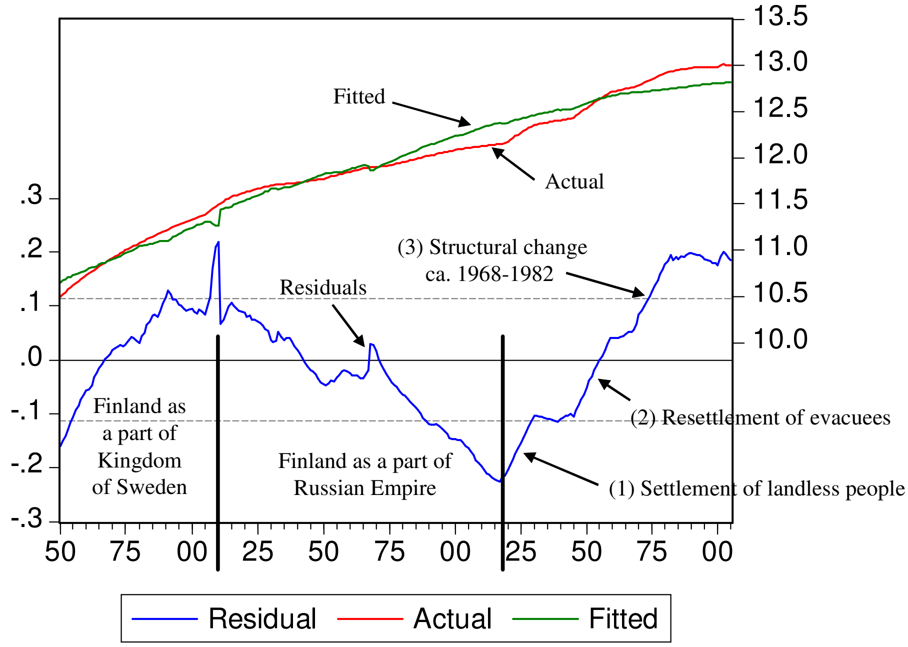


**Figure 4.** The residuals for the number of forest holdings model for years 1750-2005.

The form of model residuals from 1918 look like stairs with three rather flat steps. There are three rapid increases in the numbers of holding. After these booms, there are periods during which the number of holdings seem to increase according to the model elasticity (8.6%) with the population. Two preliminary increases in holding number, in relation to population, are seen after the WWI and the WWII. Because all tenant holdings prior to tenant farm liberalisation, and holdings located in areas of the *Winter* and *Continuation War* cessions of territories were included in the total number of holdings, a strong increase in holding number can be interpreted in two ways. First, totally new holdings were established, which was also the documented case. Second, larger holdings probably tried to maintain their property rights e.g. by sub-dividing their lands between inheritants. This is a much less studied case.

So far, the last rapid increase in the number of holdings during the 1970s looks like the most interesting of the three steps. The birth-rate was high after WWII. This generation grew up as urbanisation accelerated at the end of the 1960s. Significant emigration, especially to Sweden, was underway. Therefore, the elements responsible for a decrease in the number of forest holdings were present. Conserning agricultural holdings, a decrease was actually the case. In contrast to these, the total number of forest holdings was increasing very fast.

A partial interpretation for the increase in the number of forest holdings in the 1970s can be found in the economy. The relative value of forest-land was increasing, because the value and volume of self-employed harvesting work was decreasing due to mechanisation. Inflation was peaking after the first oil crisis of late 1973. On the demand side, monetary compensations to inheritors lost their value quickly and therefore, inheritors may have demanded fixed property instead, i.e. forestland and sites for summer cottages. On the supply side, towards the end of 1960s, Finland built a strong, progressive taxation policy for both income and property. However, agricultural and industrial sectors received alleviation from the highest progressions rather quickly, which were also peaking due to lacking inflation corrections.

Consequently, according to Sauli (1987), forestry was almost the only production sector, which remained in the highest progressive income and property taxation bracket. The effect was complemented by progressive site productivity taxation, which instead of actual incomes, was also based on forest area size, i.e. on the size of property. In addition, inheritance and donation taxation was effective for holdings, although taxation values were still employed at that time. Selling a forest holding was largely free of the taxation of profits from assignment. It is simple to conclude, that there was a supply of parts and of whole forest holdings in order to lighten the forest owners' personal tax progression, and to obtain money for tax payments and living costs.

Around 1980 the property taxation progressions were alleviated substantially. In the site productivity taxation new effective deductions were included. Holdings that continued with agriculture got a partial concession from inheritance and donation taxation. Tax concessions were introduced for self-employment in harvesting from 1979. At the same time, land purchase restrictions were introduced benefiting farmers. As a consequence, since 1982, and until 2005 the number of holdings has been increasing substantially at a rate of 8.6% with a 10% increase in population, although there have been many economic reforms and continued urbanisation since then also.

## 5. Discussion with emphasis on the present situation

The main hypothesis of this study has been that the parcelisation of forest holdings stands in relation to population growth in Finland. A very long term relationship of an 8.6% increase in the number of forest holdings with a 10% increase in population was found. In the short term, deviations from this were substantial. The results revealed that during the 1970s there was a strong parcellation phase in Finland, that can be argued to be the first one, which was *not* connected to rural settlement.

The strong parcelisation period of the 1970s had ended already in 1982. It is unfortunate therefore, that Ripatti's (1996) study on partitioning of forest holdings employed data collected just after this period. Explanations are consequently, to be drawn from economic strategy. By checking simultaneous reforms in economic programs, especially in forest taxation policy, it can be argued that extremely progressive income and property tax policies accelerated the structural change in forestry during the 1970s. In theory, supply of parts, or of whole forest holdings, due to high marginal taxation, can be caused by a disadvantage of scale. On the demand side, small-holdings may be demanded according to their more optimal scale in timber production or recreational (conservation) user values.

Compared to the United States, supply and demand factors in Finnish forest parcelisation are rather similar. However, on the supply side, solutions regarding past land-ownership questions in Finland in the 20th century, may have been affected by the uncertainty surrounding ownership property-rights. More so in Finland’s case, than in that of the United States. On the demand side, the great share of landless people with a dream of their own parcel of land, on one hand, and settlement policies on the other, have had greater affect with the question of urbanisation being less than it has been in the United States. Rather than urbanisation, a special feature in Finland since the 1960s has been the high demand for sites for summer cottages which is due to the great share of lake-land areas in forestry regions, and the relatively late urbanisation of the population. The supply of summer cottage sites has increased due to their high value, which has been reflected also in the taxation of inheritance and donation.

Different land policies affecting the supply of forest holdings, especially since the end of 19th century, have resulted in a doubling of the number of family forest holdings in Finland as compared to Sweden. The forest area owned by families is almost equal in both countries (Leppänen and Nouro 2006). Finland has over 40 percent less of a population than Sweden. The difference would be rather similar, if Finland was compared to Norway, as well.

Today, forest owners are ageing, and the share of agricultural forest owners is decreasing rather steadily. Parcelisation is not progressing differently compared to last 250 years on average. Ageing and slow parcelisation phenomena, it could be argued, are affected also by taxation. Fixed rate capital income taxation was introduced for forestry in 1993, replacing the progressive site productivity taxation. Property tax was removed in 2006. Agricultural holdings have received a tax concession for inheritance and donation tax since 1979, and it has been amended every now and then, the last time in 2004. However, this tax concession has not applied to non-agricultural forest holdings.

The conclusion reached with regard to the current forest holding parcelisation situation is as follows. Nowadays, forest owners receive scale advantages in running forestry businesses, this prevents parcelisation. Therefore, if non-agricultural forest owners maximise their forest holding profitability, they will maximise their ownership period. In 2003 agricultural forest owners were on average 49 years old, and non-agricultural forest owners 62 years old (Ripatti 2006). However, compared to agricultural holdings, due to progressive inheritance and donation taxation non-agricultural holdings are more likely to be, transferred into joint ownerships, partitioned, and turned over to recreational or conservation use.

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# The social costs of sequestering carbon on private forest lands; the case of the south-western French forest

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## Abstract :

This paper considers forestry as an approach to climate change mitigation in the forests of southwest of France. In this region, little agricultural area is available to afforest, as forest already covers the major part of the land (more than 50%). However, shifts in forest management, especially longer rotation lengths, can help to enhance carbon uptake. Many studies show that appropriate tax systems implemented on carbon uptakes by trees are an incentive to longer rotation length (see Capparos *et al*., 2003; Enzinger and Jeffs, 2000; or Hoen and Solberg, 1994), but only a few of them attempt to assess the cost effectiveness of tax systems. The aim of the present study is to provide a measure of the cost effectiveness of a tax system, implemented on forest management in south western French forests.

For a range of carbon prices between 0 and 100 euros/tC, rotations lengths vary between 51 (Faustmann rotation) and 68 years, which increases substantially carbon stocks.

The marginal costs of sequestering one ton of carbon vary between 90 and 140 euros. A sensitivity analysis shows that these costs vary positively with wood prices (higher opportunity costs to extend rotation lengths) and negatively with the discount rate.

**Keywords**: carbon sequestration, tax system, cost effectiveness, carbon sinks

## 1- Introduction

Climate change is now recognised as the major environmental threat that human kind will have to face in the next decades. The fourth assessment report published by IPCC (2007) concludes that global warming is now indisputable and that it is likely that it is due to emissions of greenhouse gas (GHG) emissions from human activities. Atmospheric concentrations of GHG are higher than any time over the last 650,000 years.

Fossil fuel use (energy generation, transport, industrial/domestic uses) remains the dominant concern, representing two thirds of global greenhouse gas emissions. Land use, including agriculture and forestry represent 31% of GHG emissions, while removing 16% through sequestration in soils and biomass (IPCC, 2007).

International action has been undertaken, the Earth summit being a starting point in 1992. Then, the Kyoto Protocol has been agreed in 1997 and has come into force since 2005. It obliges participating developed countries to reduce their emissions by 5.2% below 1990 levels, averaged over the period 2008-2012. A cap and trade system has been created. It has to be emphasised that forestry is recognised as a part of the problem and as a part of the solution as the Kyoto Protocol considers both emissions from fossil fuels use and from land use.

Under article 3-3, Annex I countries can claim carbon credits with regards to the afforested areas (induced by human activities, since 1990) (and can be debited for deforestation activities).

Article 3-4 mentions various activities potentially eligible to claim carbon credits. Grazing, pasture and forest management are some of these activities. However, the amount of carbon credits potentially eligible is limited.

But the framework of this paper goes beyond the Kyoto perspective and examines the total potential (not only the eligible potential). It has been shown that in order to stabilise GHG atmospheric concentrations at an acceptable level (which would imply an increase in the global average temperature of 2 Celsius degrees), global emissions should be divided by 2. In this context, France has set a target of reducing by 75% its emissions by 2050 (DGEMP, 2006). In this respect, none strategy must be neglected.

This paper considers forestry as an approach to climate change mitigation in the forests of southwest of France. In this region, little agricultural area is available to afforest, as forest already covers the major part of the land (more than 50% (Teruti, 2003)). However, shifts in forest management, especially longer rotation lengths, can help to enhance carbon uptake. Many studies show that appropriate tax systems implemented on carbon uptakes by trees are an incentive to longer rotation length (see Capparos *et al*., 2003; Enzinger and Jeffs, 2000; or Hoen and Solberg, 1994), but only a few of them attempt to assess the cost effectiveness of tax systems. The aim of the present study is to provide a measure of the cost effectiveness of long rotation lengths in the south west of France.

The paper is organised as follows. The first section deals with the assessment of the tax system, and the methods and data that are needed. Then, a marginal cost curve is provided, as well as a sensitivity analysis. In the third section, the assumptions made and the policy issues are discussed.

## 2- Assessing the tax system

The methodology used in this paper has been used by Sohngen and Brown (2006), then by Im *et al.* (2007). The purpose of the methodology is to measure the cost effectiveness of a tax system, based on carbon fluxes. For this purpose, we need to compare both costs and benefits of the tax system. These steps are summarised in the following paragraphs.

*2-1: Theoretical model*

Let us assume a forest owner whose objective consists in maximising the net present value of his income. His temporal horizon is infinite, as it allows to take into account the opportunity cost of land. To maximise his income, he has to choose the optimum rotation length. This model is just an adaptation of Hartmann model (1976), who considers a double forestry output; wood and environmental benefits. He shows that a forest owner paid for environmental services would extend the rotation length, beyond the economic optimum rotation length (Faustmann criteria). Many studies show that a tax system based on carbon fluxes is a factor leading forest owners to extend postpone clear-cutting (Capparos *et al.*, 2003; Enzinger and Jeffs, 2000; or Hoen and Solberg, 1994). The carbon price is assumed to be constant. Associated with discounting, this assumption has an important impact on the following results. This will be discussed further.

The maximisation problem can be written as follows

$$f(T) = \frac{-c + pv(T)e^{-rT} + \int_0^T p_c s'(t)e^{-rt}dt - p_c S(t)e^{-rT}}{1 - e^{-rT}}$$

Where

$c$ is the plantation cost; , $p$ is the timber price, $T$ is the clear-cutting age, $r$ is the discount rate, $s'$ is the marginal carbon stock change, $p_c$ is the carbon price; $S(T)$ is the total carbon stock, $f(T)$ is the function that the forest owner seeks to maximise

The first order condition states, from an economic point of view, that the rotation length is optimal when the marginal cost of waiting an additional period equals the marginal benefit of waiting an additional period. It can be written as

$$pv'(T^*) + rp_c S(T^*) = rpv(T^*) + rf(T)$$

The rotation length is longer than the optimal economic one because the marginal benefit of waiting includes a delay in the tax payment. (Capparos *et al.*, 2003; Enzinger and Jeffs, 2000; or Hoen and Solberg, 1994)

*2-2: Data*

The empirical study focuses on the mono specific maritime pine forest, which represents the major part of the total forest area. For the purpose of previous studies relative to optimise forest management in south-western French forest, the software Optimfor using dynamic programming has been elaborated[31]. The economic parameters have been provided by CRPF (CRPF, personal communication). Parameters are summarised in the following table.

Table 1: Economic parameters (CRPF, 2006)

| | |
|---|---|
| ***Plantation costs (€/ha)*** | 1200 |
| ***Clear cut cost (€/ha)*** | 90 |
| ***Thinnings costs (€/ha)*** | 60 |
| ***Annual management costs (€/ha)*** | 50 |
| ***Discount rate*** | 3% |

Wood prices are an asymptotic function of unit volumes. The basic data has been provided by CRPF (regional timber standing sales, 2005, see http://www.crpfaquitaine.fr/). The equation describing the relation between timber prices and wood volumes per unit is

$$p(v) = -9.17774v^2 + 34.6889v + 3.395182$$

where $p$ are timber prices and $v$ timber volumes per tree.

*2-3: Results:*

***2-3-1: The reference situation:***

To estimate the costs and the benefits of the tax system, it is necessary to define a reference situation. This reference situation corresponds to forest management without consideration for carbon sequestration. The focus of the forest owner is to get some incomes from wood production. This reference management is defined by the Faustmann criteria

[31] The software has been developed by C.Belle and Lysianne Guenneguez (IAE, Bordeaux). I thank them for giving me the permission to use the software.

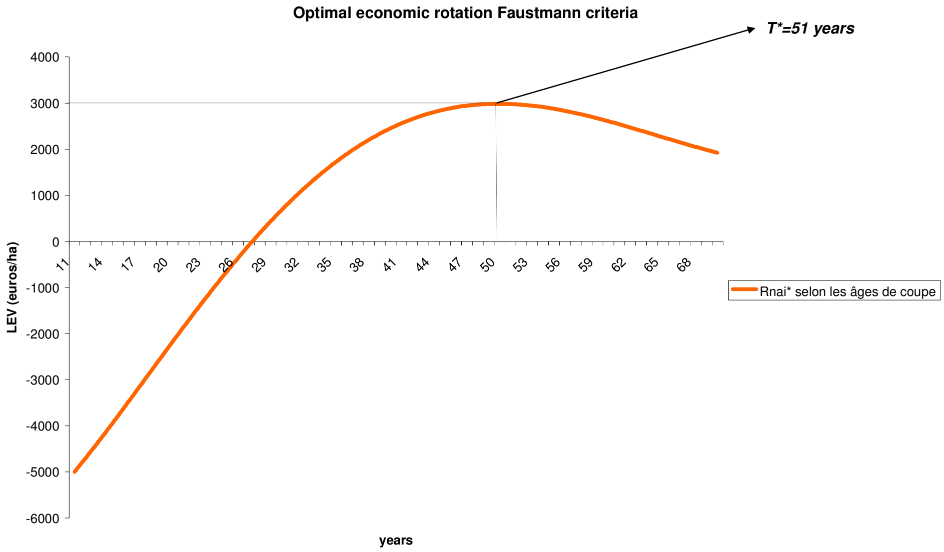


***Figure 1***: The rotation length determines the net present value of an infinite series of identical rotations. The optimal rotation length is the one that maximises the net present value of an infinite series of rotations.

The optimal cutting age is 51 years for a maritime pine stand. The land expected value is 2,957 euros per hectare. The carbon stocks are at a level of 171 tons per hectare.

Let us now consider the impacts of a tax system on rotation lengths and carbon stocks, for various carbon prices assumptions.

***2-3-2: Estimating the benefits of the tax system***

Several approaches have been suggested in the literature (see Richards and Stokes (2004) for a detailed review).

Flow summation involves summing annual carbon flows over a given number of years, but the choice of ending dates can be quite arbitrary and has a substantial impact on the results.

The average storage approach involves averaging carbon stocks over a given number of years.

The problem with the average storage approach is that it does not consider intertemporal issues associated with carbon sequestration and forestry. We can consider for instance that early sequestration has a greater value than late sequestration; this could be related to the idea of biological sequestration as a mean to buy time, while waiting for new technologies, “climate friendly”. To take it into account, some have used discounting techniques to estimate the carbon benefits of forestry. The main advantage of this methodology lies in the possibility to compare “fairly” mitigation projects through forestry and other mitigation projects, within the energy or industrial sectors. Another interest is that benefits (for the forest owner) of getting new sources of income are compared to the benefits (in terms of carbon storage) on an identical basis (Sonhgen and Brown, 2006).

The framework of this study is the one of an existing forest. For this reason, quantities sequestered under the assumption of a traditional rotation (until the forest stand reaches 51 years) should not be considered as a benefit of the tax system. Those quantities would have been sequestered without the tax system for the purposes of wood production. These quantities are not taken into account in this study.

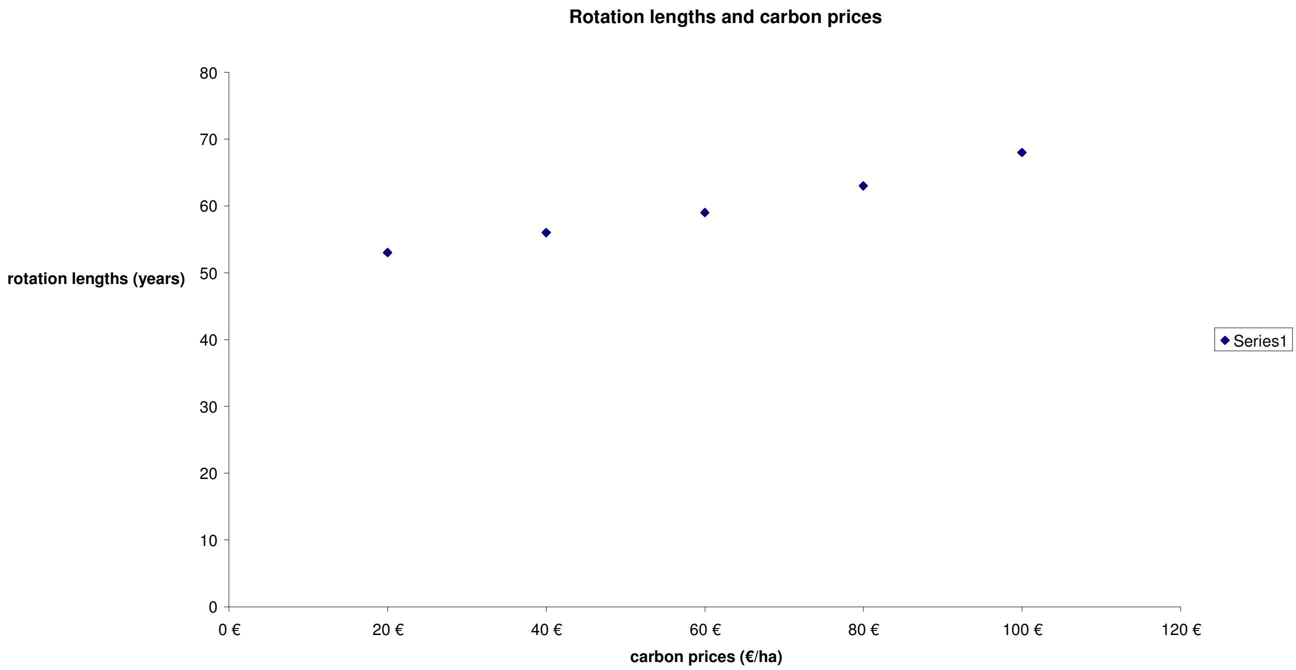


***Figure 2:*** Carbon prices and the impact of a tax system:

### *2-3-3: Estimating the costs*

Tax system costs are simply constituted by the present value of the amount of money provided by the society to the forest owner.

Table 2: Carbon prices, rotation lengths and tax system costs:

| Carbon price (€/Ton) | Rotation length (years) | Cost (present value/ha) |
|---|---|---|
| 20 € | 53 | 981 € |
| 40 € | 56 | 2,079 € |
| 60 € | 59 | 3,343 € |
| 80 € | 63 | 4,868 € |
| 100 € | 68 | 6,443 € |

## 3- The marginal costs estimates:

### *3-1: The marginal cost curve*

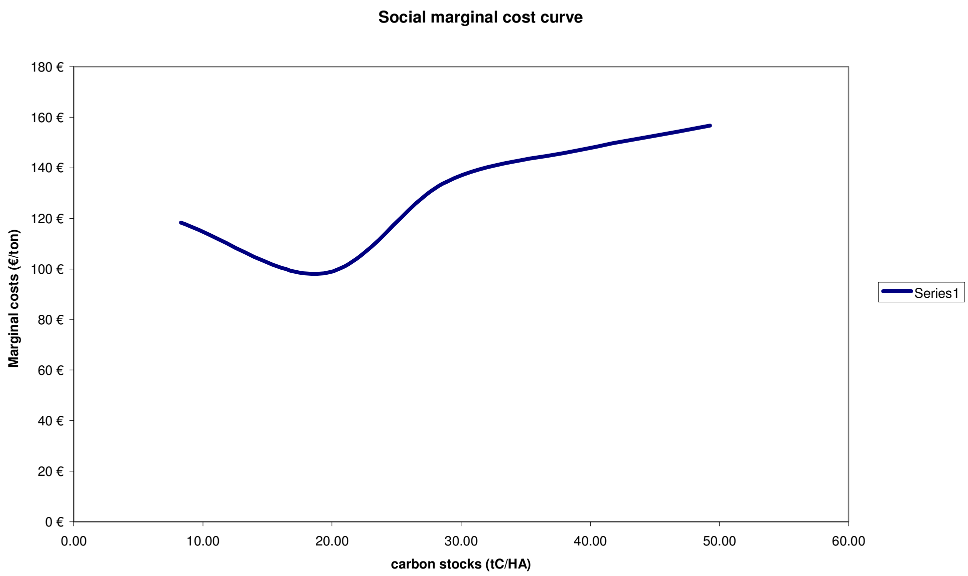


***Figure 3:*** The marginal cost curve is relatively flat. The decreasing shape of the curve could be explained as follows. Intuitively, we would expect a rising cost. As long as the trees get older, less and less quantities are sequestered (due to a slower growth, and the impact of discounting), diminishing by the way, the benefits of the tax system.

However, we assume that wood prices increase as a function of trees volumes. As a consequence, for a carbon price of 30 euros/ton (additional carbon stocks = 20 tons), another effect, under the form of an increase in timber prices, provides an incentive to the forest owner to extend the rotation length.

Then as timber prices are an asymptotic function of wood volumes, that trees growth slows, the benefits of the project tend to increase at a lower rate than the costs, which explains the increasing shape of the curve.

The marginal costs of sequestering one ton of carbon vary between 90 and 140 euros. The costs seem relatively high (between 24.5€ and 38€ per ton of Co2), compared to the general assertion considering forestry as a least cost mitigation option. It is due to the fact that the benefits of the system, in terms of carbon storage, exclude the quantities sequestered until the stand reaches its optimal age according to Faustmann criteria. These quantities are not considered as additional. However, the values are comparable to values for other regions of the world, Oregon, California, see Sohngen and Brown, 2006).

*3-2: Sensitivity to timber prices.*

When the forest owner tries to maximise his income with regard to the value of wood production, an increase in wood prices conducts him to decrease rotation length (he can get the same income on a shorter time scale). Payments for carbon sequestration provide him an incentive to postpone clear-cutting. As a consequence, as timber prices increase, the competition between wood production and carbon sequestration becomes more important and the opportunity cost of sequestration increases. Low value forest areas (public forests managed for other purposes, as coastal protection) could be used, instead of private forests, for the purposes of carbon sequestration.

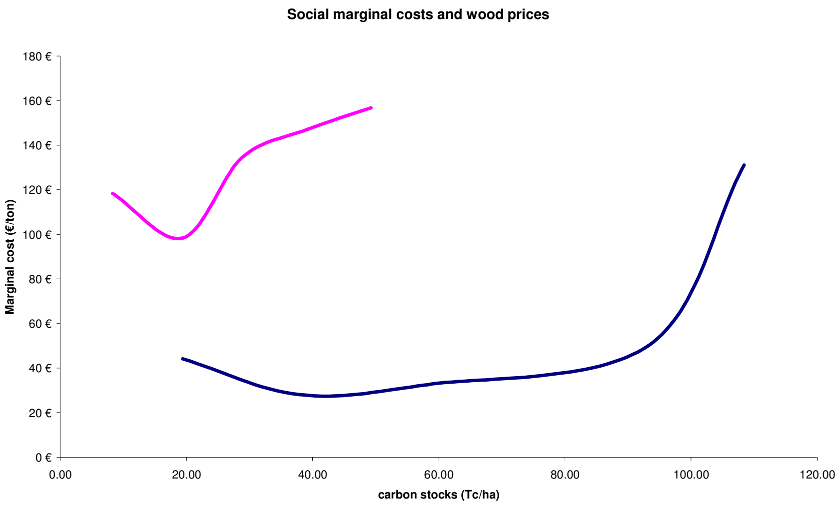


***Figure 3***: The social costs of carbon sequestration and timber prices

*3-3: Sensitivity to the discount rate:*

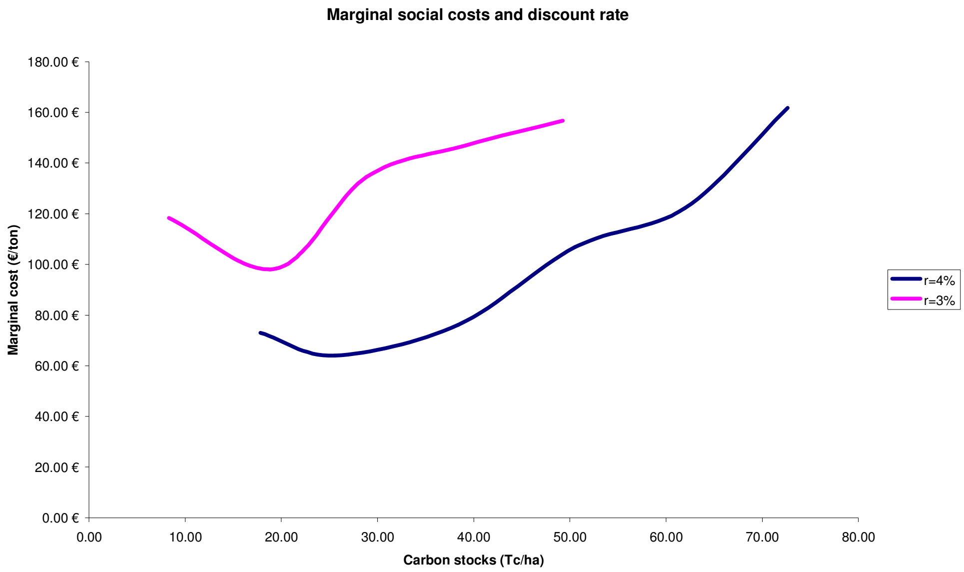


***Figure 4:*** Social costs of carbon sequestration and discount rate. As the discount rate increase, the share of carbon sequestration incomes in the total income of the forest owner and this one seems to be more reactive to the implementation of the tax system. Therefore, sequestering carbon by extending rotation lengths seems to be less costly as the discount rate increase.

*3-4: A comparison between the private opportunity cost and the social opportunity cost:*

An interesting measurement of the cost effectiveness of the tax system is to compare the social opportunity cost to the private opportunity cost that would face the forest owner.

The costs have been estimated according to a comparison between the land expected value when the rotation length is optimal and the land expected value when the rotation length is longer. Benefits are estimated by the same methodology as described in section 1.

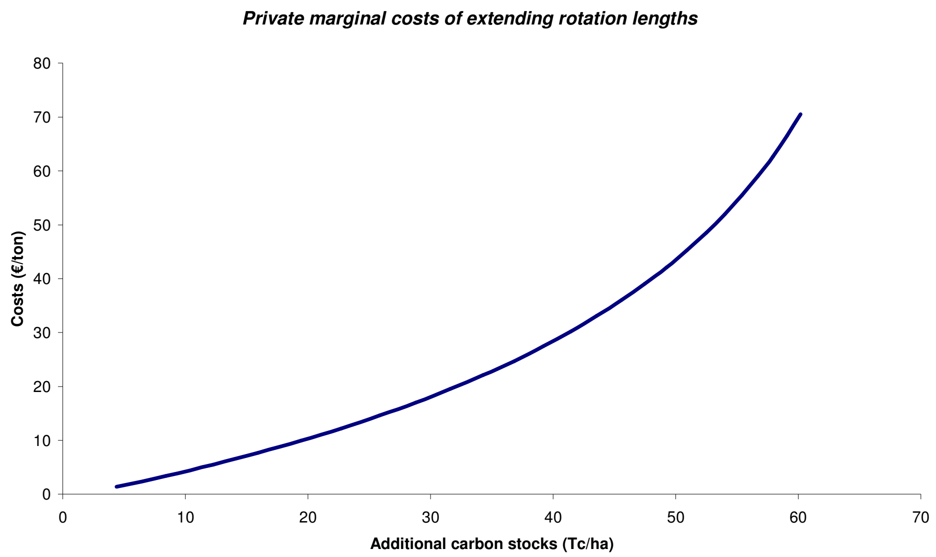


***Figure 5:*** The private marginal costs of carbon sequestration by extending rotation lengths. We can see there is an important difference between the private and social marginal costs, as the private costs range from 2 to 70 euros per ton of carbon.

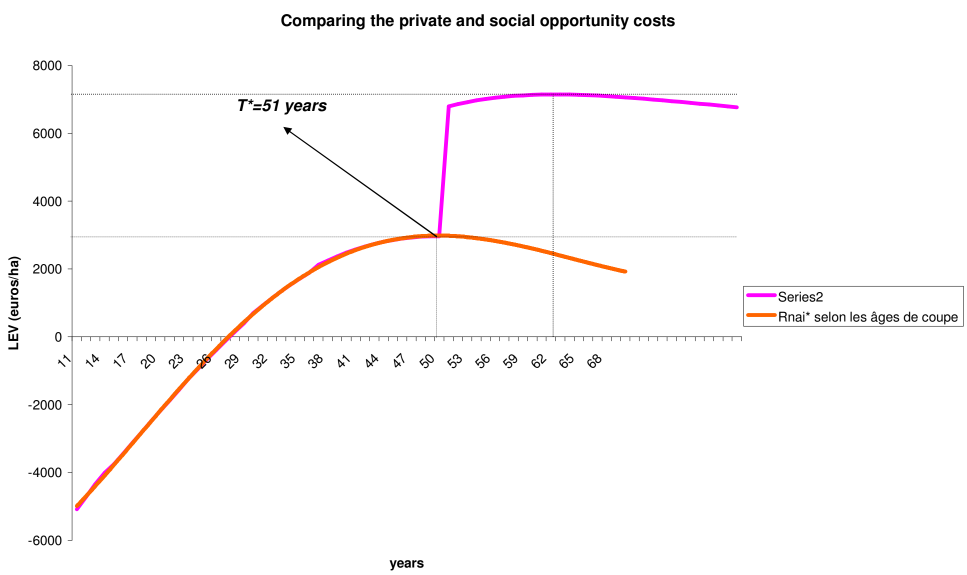


***Figure 6***: A comparison between the incomes (related to rotation lengths) received by the forest owner in the two situations. The red curve is the NPV of wood production over an infinite series of rotation. The pink curve is the additional income received for carbon sequestration. The area between the two curves is the social cost.

## *4- Discussion*

The study provides some estimates of the costs of sequestering additional carbon in existing and actively managed forests (during the period 1988-1998, 94% of the annual increment has been harvested).

The cost effectiveness of a tax system has been assessed by a comparison between its social costs and its social benefits. The results show that sequestering carbon in these forests is relatively costly, while comparable to the costs in other parts of the world.

Timber prices increases have an impact on carbon sequestration costs through the opportunity costs of extending the rotation beyond the optimal economic one. An increase in timber prices means an increase in the opportunity costs of carbon sequestration.

An increasing discount rate reduces the land expected value; and its opportunity cost. By the way, the social costs of carbon sequestration are lower than with a low discount rate.

A comparison between the social and the private marginal cost of extending rotation length has been done. It shows that the cost of the tax system is far beyond the private opportunity costs faced by the forest owner. It means that with regard to the costs involved, the benefits do not appear so important.

Several limitations can be mentioned:

- The first is relative to the carbon price, which has been assumed constant. Assuming a falling carbon price is the same as assuming that in the next decades, climate change problem will be solved. However, many factors can affect carbon prices. Conjectural factors (energy demand linked to weather conditions for instance) explain monthly or seasonal variations. A structural factor is technology (geological sequestration, hydrogen, hybrid vehicles). The other main factor is the political will to tackle climate change; which should be expressed as a restricting limit on Co2 emissions. If technology is not improving enough in the next decades and/or the constraint on Co2 emissions is at a high level, demand for carbon credits will be at a high level and the carbon price will rise. In the case of a rising carbon price, the social costs of carbon sequestration would be higher, as well as the private costs. We can show that a rising carbon price generates negative incomes for the forest owner. Therefore, rotations lengths are reduced, by the way, creating a counter productive tax system (as in this case, it could be anticipated that less areas should be forested).
- The second is based on the underlying assumption regarding the discount rate. A constant discount rate implies the early benefits to be worth more than the late benefits (and the late costs). However, the physical cost of a ton of Co2 emitted now or in a few years will remain the same. Actually, it could even be worse, as it is expected there are, with the increase in Co2

atmospheric concentration, some cumulative and irreversible effects. Therefore, the assumption of a constant discount rate is equivalent to the one of a decreasing carbon price. It assumes that the climate change problem will be solved (at the scale of a rotation, i.e. 50/60 years) and that early sequestration is definitely better than late releases. But it could be the case that late releases could also be costly, and it is not reflected by the use of a discount rate.

- Third, the tax system would presumably generate high transaction and monitoring costs. For simplification purposes, these costs have been excluded.
- The 1999 storm damaged in the south west of France more than hectares, in variable proportions, felling down around 16% of wood volumes and carbon stocks. In a broader sense, the storm raised the issues of risk and vulnerable stands (to diseases, storms or fires) because longer rotation lengths are potentially a more risky situation. This should be considered as a factor increasing the costs of carbon sequestration.
- Finally, relatively to wood products, two issues affect the robustness of the model. between 1988 and 1998, 94% of the mean annual increment of the maritime pine forest has been harvested. This has allowed the storage of significant quantities of carbon in wood products (3% of the biomass carbon stocks, according to Malfait *et al.*, 2003). Longer rotations lengths should reduce the harvesting rate and the carbon stocks in wood products. The second issue (that could help solving the first) about wood products is that, in this study, they are not considered as a benefit of the tax system. However, there are two ways to think about the benefits of the wood products. First, it is an additional storage capacity (compared to storage in trees). Then, wood products substitute to $CO_2$ intensive materials (as concrete or steel in the building sector), and this represents a benefit to the society.

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# Kemera Supports and the Profitability of Small-Diameter Energy Wood Harvesting from Young Stands in Finland

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## Abstract

In order to speed up the production of small-sized thinning wood chips in young stands, the Finnish State provides financial incentives for the production of small-diameter wood chips. Financial support is provided according to the Sustainable Silviculture Foundation Law (Kemera). Currently (Summer 2008), the Kemera support provides subsidies for small-sized wood chips in early thinnings 7–10 €/MWh maximum in typical harvesting conditions (whole-tree chip removal 40–70 $m^3$/ha, and average stem size of removal 10–40 $dm^3$). Metsäteho Oy undertook a study on the total production costs of small-sized thinning wood chips with and without the Kemera supports. The results gave a clear indication that small-sized wood chips cannot currently be produced without the Kemera supports from young stands with typical harvesting conditions. If operating without the Kemera supports, the average stem size of whole trees harvested must be greater than 80 $dm^3$, at the current price level of small-diameter wood chips in order for the harvesting of small-diameter energy wood from young stands to be economically profitable in Finland.

**Keywords:** Support policy, Costs, Small-diameter wood, Energy wood, Harvesting, Early thinnings.

## 1. Background

In Finland, 3.0 million $m^3$ (6.1 TWh) of forest chips were used in 2007 (Ylitalo 2008). Of this amount, 87% was used by energy plants and the remaining portion by small-sized dwellings (Ylitalo 2008). Only one quarter (0.7 million $m^3$) (1.4 TWh) of the total amount of commercial forest chips used for energy generation was produced from small-sized trees in young stands (Ylitalo 2008).

When harvesting small-sized thinning wood in young stands, the stem size harvested typically has a breast height diameter ($d_{1.3}$) of less than 10 cm, and the stems are harvested as whole trees (stem with branches) (e.g.

Kärhä 2006, Kärhä et al. 2006). In Finland, typical harvesting conditions in early thinnings may be described as where whole-tree chip removal is around 40–70 $m^3$/ha and the average stem size of removals in stands ranges between 10–40 $dm^3$ (Kärhä et al. 2006). It has been estimated that the stock of technically harvestable small-sized thinning wood in young stands is 3.5–7.0 million $m^3$ (7–14 TWh) annually (Hakkila 2004, Leino et al. 2007, Ranta et al. 2007, Laitila et al. 2008). In Finland, the annual use of forest chips for energy generation is to be increased 10 TWh (5 mill. $m^3$) by 2010, and 16–24 TWh (8–12 mill. $m^3$) by 2015 (Anon. 2003, 2008a). These goals presuppose that the harvesting volume of small-sized thinning wood is tripled, or even quadrupled, from the current harvesting volume.

In young stands, high harvesting costs, particularly cutting costs, are the primary problems in early thinnings. The small stem size, low removal per hectare and harvesting site, and dense undergrowth, result in low productivity and high cutting costs (e.g. Kärhä et al. 2005, Kärhä 2006, 2007a, Laitila 2008, Oikari et al. 2008). When producing whole-tree chips in young stands, the total supply chain costs are approximately 17–21 €/MWh. In the beginning of 2008, the mean price of forest chips at the plant was 14.4 €/MWh in Finland (Anon. 2008b). In order to speed up the production of small-sized wood chips in young stands, the Finnish State provides production subsidies for small-sized wood chips in early thinnings, according to the Sustainable Silviculture Foundation Law (Kemera) (Anon. 2007).

In Finland, two mechanized harvesting systems are used for small-diameter energy wood: 1) the traditional two-machine (harvester and forwarder) system, and 2) the harwarder system (i.e. the same machine performs both cutting and forest haulage to the roadside) (Kärhä 2006). At the present, there are close to 200 small harvesters (weight <13 tons) and harvesters for thinnings (weight 13–15 tons) cutting small-diameter thinning wood in Finland (Kärhä 2007b). In addition, there are around 50 energy wood harwarders in early thinnings.

Metsäteho Oy undertook a study on the total production costs of small-sized thinning wood chips with and without the Kemera supports. This seminar paper introduces the Kemera support system for energy wood harvesting in early thinnings in Finland, and presents the effect of the Kemera supports on the profitability of whole-tree chip procurement.

## 2. Kemera support system

The Kemera support is paid only for young forests owned by non-industrial private forest owners (Anon. 2007, 2008c). The Kemera support is paid for both the non-industrial private forest owner's own work, as well as for contracted work. The area, to be eligible for the support must be greater than 1 hectare (Anon. 2007, 2008c). A principal element in the Kemera support system is that supports provided are restricted to be given only once throughout a stands rotation cycle (Anon. 2007, 2008c). There are currently four support instruments offered for young stands in the Kemera support system:

1) Support for thinning young stands,
2) Support for small-sized wood harvesting,
3) Support for chipping, and
4) Support drawing up a work clarification (Anon. 2008c).

*Support for thinning young stands:*

- The support is paid for thinning operations of the stands second development class.
- Removal of trees at stump diameter ($d_0$) greater than 4 cm must be over 1,000 trees per hectare.
- The average $d_{1.3}$ of remaining trees has to be less than 16 cm after thinning operations.
- After the thinning operation, the height of dominate trees cannot exceed 14 m in Scots pine (*Pinus sylvestris* L.) and Norway spruce (*Picea abies* (L.) Karst.) dominated stands, and no more than 15 m in broadleaf stands. If wood is used for energy generation, the height may be increased.
- The density of remaining production trees must be 700–1,400 trees/ha according to tree species after a thinning operation. If the initial stand is dense and there is a risk in damaging remaining trees, the density of remaining trees may be 2,000 trees/ha maximum.
- There is no immediate need for industrial roundwood harvesting (i.e. first thinning) after a thinning operation, and the support is not paid for the pre-clearance operation of a first thinning.
- The amount of support provided depends on the Kemera support zone (Fig. 1, Table 1).
- If the forest owner has no valid forestry plan, the support will be lowered by 10%.
- The grantee of the support is a non-industrial private forest owner.

*Support for small-sized wood harvesting:*

- The support is paid for:
  *i*) wood which comes from the tending of young stands.
  *ii*) when energy wood removal is more than 20 $m^3$.
  *iii*) when wood is to be used for energy generation.
- The amount of the support is 7 €/$m^3$ (3.5 €/$m^3$ for bunching operation, and 3.5 €/$m^3$ for forest haulage).
- The grantee of the support is a non-industrial private forest owner.

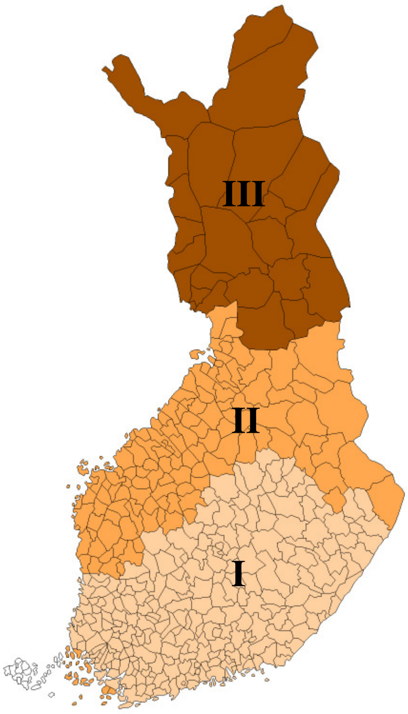


**Figure 1.** The Kemera support zones I–III in Finland. © Affecto Finland Oy, L7507/08.

**Table 1.** The amount of support for thinning young stands by the Kemera support zone and party completing the work.

| | Support zone | | |
|---|---|---|---|
| | I | II | III |
| | Support, €/ha | | |
| Forest owner conducts own work | 135 | 162 | 189 |
| Work is conducted by paid labor | 210.5 | 252.6 | 294.7 |

*Support for chipping:*

- Support is paid to the supplier of wood chips (e.g. energy wood procurement organization, chipping machine entrepreneur, heat entrepreneur, local forest management association) after the energy plant has received wood chips, paid in full.
- The amount of the support is 1.7 €/loose $m^3$ (4.25 €/$m^3$).

*Support for drawing up work clarification:*

- The Kemera supports for thinning young stands and small-sized wood harvesting are paid only after a work contract has been completed based on the application submitted to the forestry centre. The application must include clarification of a work contract.
- The support for work contract clarification may be paid if work is verified by someone other than the forest owner (e.g. officer of local forest management association or forestry centre).
- If the tending area in a young stand is greater than 2.6 ha, the support is 78 € + 16.5 €/ha. If the area is less than 2.6 ha, the support is 46.5 €/ha.
- If small-sized wood is to be used for energy generation, an additional energy wood harvesting support of 4.6 €/ha is applicable.
- Support for the clarification of chipping work is 0.1 €/loose $m^3$ (0.25 €/$m^3$).

When assuming that:

- A non-industrial private forest owner has a valid forestry plan.
- The forest owner does not carry out work activities.
- Work activities are conducted according to guidelines.
- Size of stand is 3.0 ha.
- Whole-tree removal is 50 $m^3$/ha (150 $m^3$/stand) (cf. Kärhä 2006).

Then the maximum total support is 2,498–2,750 €/stand depending on the support zone (Table 2). The largest support instruments are the supports for small-sized wood harvesting, the support for thinning young stands, and the support for chipping (Table 2). In confirming work clarifications, the level of support provided is smaller. The maximum total support per harvested cubic meter is around 17–18 € (8–9 €/MWh).

## 3. Cost calculations

When drawing up the total production costs of small-sized whole-tree chips with and without the Kemera supports, the following cost factors were applied:

- Stumpage price: 4.0 €/$m^3$
- Cutting costs: 48.1 €/$m^3$ (5 $dm^3$) … 5.2 €/$m^3$ (80 $dm^3$)
- Forwarding costs (250 m): 6.0 €/$m^3$ … 5.6 €/$m^3$
- Chipping costs: 7.5 €/$m^3$
- Road transportation costs: 4.0 €/$m^3$ (20 km) … 7.7 €/$m^3$ (120 km)
- Overheads: 2.5 €/$m^3$.

**Table 2.** The calculation of the maximum Kemera support for the stand by the support zone (cf. Fig. 1).

| Kemera instrument | Support zone | | |
|---|---|---|---|
| | I | II | III |
| | €/stand | | |
| Support for thinning young stand | 632 | 758 | 884 |
| Support for small-sized wood harvesting | 1,050 | 1,050 | 1,050 |
| Support for chipping | 638 | 638 | 638 |
| Support for drawing up a work clarification | | | |
| - Basic support | 128 | 128 | 128 |
| - Added support for small-sized wood harvesting | 14 | 14 | 14 |
| - Added support for chipping | 38 | 38 | 38 |
| TOTAL | | | |
| - €/stand | 2,498 | 2,624 | 2,750 |
| - €/ha | 833 | 875 | 917 |
| - €/m$^3$ | 16.7 | 17.5 | 18.3 |
| - €/MWh | 8.3 | 8.8 | 9.2 |

# 4. Results

## 4.1. Profitability without the Kemera supports

When calculating the total production costs for whole-tree chips, it was noted that production costs were relatively high, 35–43 €/m$^3$ (17.5–21.5 €/MWh) in average harvesting conditions (average size of removed whole trees: 20–30 dm$^3$) of young stands compared to the average price of forest chips at the gate of energy plants (14.4 €/MWh) (Fig. 2).

The results indicated that whole-tree chips from early thinnings with typical harvesting conditions cannot currently be produced in an economically profitable manner without the Kemera supports. If operating without the Kemera supports, the average stem size of whole trees harvested must be around 80 dm$^3$ with relatively short road transportation distances, assuming that stumpage price is 4 €/m$^3$ (Fig. 2).

## 4.2. Profitability with the Kemera supports

When including the total maximum Kemera supports (Table 2) for the production costs of whole-tree chips (Fig. 2), the production of whole-tree chips was also economically viable in young stands where the average stem size of removal was less than the average (20–30 dm$^3$) (Fig. 3). In the large-sized young stands (i.e. the average size of removal 40–60 dm$^3$), the production of wood chips from early thinnings appeared to be relatively profitable. However, it must be noted that the Kemera support cannot be provided for these types of stands, because of the remaining large-sized tress in the stand after a thinning operation.

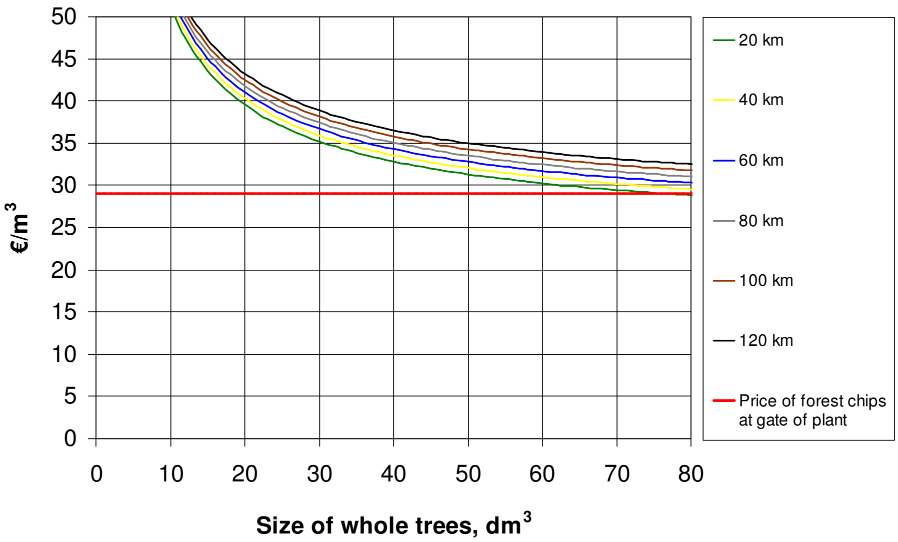


**Figure 2.** Total production costs of whole-tree chips as a function of the size of whole trees harvested from early thinnings, as well as the average price of forest chips (14.4 €/MWh) in the beginning of 2008 in Finland.

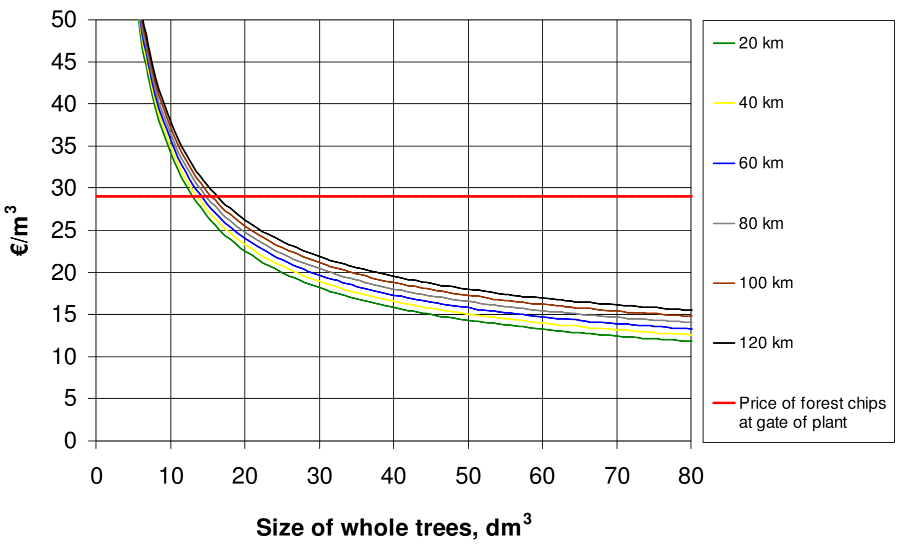


**Figure 3.** Total supply chain costs of whole-tree chips in early thinnings when including the Kemera supports of 17 €/$m^3$ (8.5 €/MWh) for production costs (see Fig. 2).

## 5. Discussion and conclusions

The cost calculations illustrated that small-sized wood chips (whole-tree chips) cannot currently be produced without the Kemera supports from young stands with typical harvesting conditions. When operating without the Kemera supports, the average stem size of whole trees harvested must be greater than 80 $dm^3$, at the current price level of small-diameter wood chips in order for harvesting of small-diameter energy wood from young stands to be economically profitable in Finland. When the average stem size of whole trees is approximately 80 $dm^3$, the stand is typically a small-diameter first-thinning stand for industrial roundwood (pulpwood) harvesting in Finland.

Also, the results indicated that small-sized thinning wood can be harvested from relatively poor harvesting conditions (the average size of whole trees 15–20 $dm^3$) with the Kemera supports. State authorities justify the levels of Kemera supports by stating the aim of the Kemera support system, which is to encourage recovery of small-diameter thinning wood for energy generation, which also includes harvesting poor quality sites.

There are several ongoing discussions that the Kemera support system would direct pulpwood for energy generation instead of pulping. Currently, there hasn't been research which has studied the amount of industrial roundwood (i.e. pulpwood) being allocated for energy generation within the Kemera system. Furthermore, it should be noted that guidelines determine very clearly that the average $d_{1.3}$ of remaining trees must be less than 16 cm after a thinning operation, which eliminates wood harvesting operations for energy generation from relatively large-sized early thinnings with the Kemera supports (Anon. 2008c).

The production support (Kemera) for wood chips from small-diameter thinning wood is required today, as high harvesting costs hinder the profitability. In the future, the level of Kemera supports will be lower, as funding levels provided from the State are not likely to increase, even with increasing levels of non-industrial private forest owners applying for the support. In looking at future prices, the price of forest chips will likely increase and improve the competitiveness of small-sized chip production from young stands with lower levels of Kemera supports. Increased development in supply chain and harvesting efficiency will likely increase the profitability of harvesting small-diameter wood and should be encouraged.

On the other hand, the production costs of small-sized wood chips in early thinnings will increase in the future when harvesting operations are expanded to include smaller and poorer quality sites, (i.e. less removals, more difficult terrain, and longer forwarding distances) which means increased cost pressures on the supply costs of small-diameter wood chips (Kärhä 2007c).

When discussing the Kemera supports, it must be noted that they play a very important role in Finland, so that young stands are managed in a way that promotes healthy silvicultural conditions. Without the Kemera support system, it can be estimated that there would be greater occurrences of untended young stands in Finland. In Sweden, for instance, where there is no similar support system for young stands, such as Finland's Kemera system, there are currently significant silvicultural problems with their young, dense and small-diameter stands (Nordfjell et al. 2008).

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# First Movers, Non Movers and Social Gains from Supporting Entry in Markets for Nature-Based Recreational Goods

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## Abstract:

In general most nature-based recreational goods and benefits are considered positive externalities of production, as they are usually not subject to trade. So far, a low degree of rivalry among most user groups and legally defined rights has secured these benefits as almost a public good. Yet, the increasing intensity of use and the arrival of new demanding user groups are quickly changing the picture. In some regions, rivalry among user groups is strong, changing the situation to one of a common-pool resource and declining quality of the good. This provides an option for landowners to offer tailored goods and services to specific user groups, offering to improve the quality of their recreational experience against a payment.

Using a two-stage game theoretical model, we show that in spite of apparent potential first-mover advantages in this developing market, demand uncertainty and sunk costs may equally well result in widespread presence of non-movers on the supplier side. While most of the first-mover literature analyse the potentials for sustained first-mover gains, we focus on the presence of non-movers. In a simple model, we show that social gains can be made from offering a subsidy towards the sunk costs. The efficient scheme takes into account the underlying first-mover game.

**Key words:** First-mover advantage, game theory, sunk costs, demand uncertainty, fixed supply, public procurement, rationing.

## 1. Introduction

This paper explores the development of and entry into new markets for nature-based recreational goods by small private enterprises, and the condition for social gains to be made from supporting such development and entry.

The multiple benefits of nature as a resource for recreational and leisure activities have received increased attention and in many countries this use has been steadily on the rise for decades (Jensen and Koch, 1997). In many countries, well-defined and widespread access rights have meant that the typical recreational goods enjoyed by users has essentially been an externality produced by forests and other nature areas, be they publicly or privately owned. Due to market failure the production of these externalities may be below the social optimum, and this may explain why some countries provide enhanced recreational access and goods on state owned land or implement less restrictive access rights in general. To the extent that these goods are non-excludable and non-subtractable, they can be characterized as public goods.

However, the continuous growth in outdoor recreation activities and in particular the recent decades' growth in still more demanding activities like mountain biking, snow-mobile riding and ATV-driving (Mantau et. al., 2001; Vail and Hultkrantz, 2000; Vail and Heldt, 2004), has left some recreational areas and services more of a common-pool resource than a public good. Also the increase in less demanding activities such as groups performing live-action role-play, people taking their dogs out and local sport/outdoor clubs are increasingly putting pressure on local forests and nature areas. The recreational experience enjoyed by hikers, bird-watchers and the like may be affected negatively by the activities of the more action-based user groups (Vail and Hultkrantz, 2000; Vail and Heldt, 2004), leading to conflicts and rivalry and in turn decreasing the value of the recreational experience for all user groups. In other areas, e.g. on privately owned land, such activities are not permitted or severely restricted. This development opens up the opportunity that private enterprises owning forests and other recreational areas develop tailored services for specific recreational user groups, offering them recreational access rights and experiences that are legal, of a higher quality than otherwise available and nevertheless does not impede on the rights of and benefits enjoyed by others.

As with all new markets, private enterprises may consider the option to enter the market early in order to obtain a first-mover advantage. First-mover advantages may in general be obtained and sustained for some time for several reasons, e.g. entering first may create buyer-switching costs, asymmetric information advantages and behavioural barriers which raise costs for followers (Lieberman & Montgomery, 1988; Kerin et. al., 2001). For the type of recreational facilities and services in focus here, it can be argued that first-mover advantages may in fact be present. Nevertheless, empirical evidence seems to suggest that the development of these markets appears to be slow and patchy (Mantau, et. al., 2001; 2001a).

A first question addressed in this paper is what may explain this lack of market development? There may be several explanations, including the possibility that private enterprises simply do not expect an entry to pay-off under any circumstances. However, given the apparent increase in nature-based recreational activities, this seems an unsatisfactory conclusion, and we may benefit from considering other explanations. Therefore, in this paper we develop a model of the market entry decision, which includes standard first-mover advantages (Lieberman & Montgomery, 1988), but also other aspects which may explain why it may be optimal for the firms to wait. These aspects are the presence of irreversible sunk costs of entry, indivisibility of supply, demand uncertainty *a priori* and the option to obtain certain information on the demand state once a supply has been established.

We build these aspects into a two-player non-cooperative Bayesian simultaneous-move game in two stages with strategic interaction between the players (Mas-Colell et. al., 1995). We derive the classic conditions for firms to pursue first-mover advantages, but we also show how in fact 'non-moving' may indeed be fairly widespread and agents essentially may very well sit and wait for information to come along before deciding on entry.

This observation gives rise to two additional questions: Can there be social gains from intervention and supporting the development of such markets? And if yes, then when and how such intervention could be best performed? These questions relate to the issue of public procurement of products and services. Public procurement is widespread, and obvious cases include public goods like defence or environmental goods, but also goods like health care and cultural goods. While public or state ownership or supply is sometimes feasible in this setting, e.g. public ownership of near-urban forest and nature areas and national parks, there a numerous cases where society finds it useful to secure a supply from private agents by creating incentive schemes for output of the good. Examples are the subsidies that are paid to landowners, who supply environmental goods, subsidies for dental care, health care etc.

We answer the questions raised here by determining conditions for which public procurement will be optimal, and the socially efficient procurement schemes maximising social benefits net of social costs, subject to agents reacting with supply.

The reminder of the paper is structured as follows. In section two we outline key characteristics of the recreational goods in focus here. We furthermore relate this to the theory on obtaining and sustaining first-mover advantages in new, developing markets, and we also outline the main issues addressed in the literature on public procurement and how our results relate to this. In section three we present the main parts of the model developed, and we use these to derive the results presented in section four. We discuss our results and the contribution they make in section five, where we indicate likely implications for policy design to follow from further analyses and of course highlight key limitations of the approach taken and results derived. In section six we make a few concluding remarks.

## 2. Theory

***2.1 On the nature of nature-based recreational goods***

The general classification of goods was influenced by Samuelson (1954) who first suggested subtractability or rivalry as the one attribute to divide all goods into either public or private goods by, with the latter group being goods where one person's consumption subtracts from the total consumption available. Musgrave (1959) challenged this and suggested that whether or not someone can be excluded from benefiting from the good should be used as attribute for dividing goods into public or private goods, with the latter being goods where exclusion is possible. They both aimed at creating a classification which could predict when markets would perform optimally and when they would fail. Later on, a combination of their classifications has been used where goods are classified into four types according to both rivalry and excludability (Ostrom 2003). Figure 1 presents the resulting classification.

| | **Non-excludable** | **Excludable** |
|---|---|---|
| **Rivalry** | Common-pool resources | Private goods |
| **No rivalry** | Public goods | Club goods |

*Figure 1. Classification of goods (based on Ostrom (2003), Musgrave (1959) and Samuelson (1954))*

The relevant access rights combined with the type of recreational use will be the major determinants for what type of good a given recreational good or services will be (according to figure 1), because it has implications for excludability as well as rivalry. Moreover, nature-based recreational goods often have characteristics which relate them to both services and manufactured goods which lead to different first-mover advantages. This has implication for the potentials for market development. An example: In Denmark, individual hiking is allowed on all forest land, and hence exclusion is not possible. Without rivalry, this is a public good. And indeed no marketed goods like access to hiking trails exist in Denmark. Horseback riding, however, is only allowed in some state-owned forests, not in private forests. Thus, exclusion is possible, and in fact a well-developed private market for individual or club-based horseback riding licences exist, the annual fee being in the range of 100-200 € (Lund et. al., 2008).

The degree of rivalry also has implications for the nature of recreational goods and in turn the potential for developing marketable goods and services. Increasing recreational use of nature areas, and in particular increases in intensive and demanding activities like ATV and snowmobile riding as well mountain bike racing is causing rivalry among recreational user groups (Vail and Hultkrantz, 2000; Vail and Heldt, 2004; Lund et. al., 2008). This happens because of congestion and the presence of externalities related to use type; the consumption of one individual affects the consumption option of another. Rivalry makes the recreational good a common-pool resource. This may create an option for developing e.g. specialized trails for mountain bikers and other demanding user groups, which may be willing to pay for such improvements in their recreational experience.

The main challenge for the private enterprise in entering this market will often be to increase the level of excludability in order to make the good marketable. Mantau et. al. (2001a) investigated the emerging markets for recreational and environmental goods in several European countries and found that indeed a majority of the cases concerned goods related to recreation; concluding that the possibility to establish excludability is a key determinant (Merlo et. al., 2000). Ability to establish excludability makes it possible to market goods in the form of club or private goods. These studies also documented, however, that market development is very incomplete and patchy and varies greatly across regions. This may reflect the fact that most user groups are not willing to travel far (Jensen & Koch, 1997), and hence markets are likely to be quite regional in turn implying that potential suppliers may be few, and that information on demand can only be obtained locally, and hence remains uncertain until a supply is established (e.g. Chatterjee and Sugita, 1990). Furthermore, the supplier may not be able to vary the quantity supplied - half a mountain bike trail does not make much sense. Thus supply cannot be adjusted to the observed demand unless in fixed quantities. Finally, if entry implies sunk cost, e.g. for establishing recreational facilities, then this may further explain the sluggish development. These dis-incentives may be counterbalanced by the potential of entering first and enjoying first-mover advantages.

### *2.2 First-mover advantages*

First-mover advantages refer to the benefits gained from pioneering in a field, e.g. by entering a new market, introducing a new product or a new process through innovation and R&D. Important early contributions have focused on the role of pioneering in establishing brands (Schmalensee 1982) or the role of first-mover advantages in halting or enhancing innovation (Reinganum 1981, 1983). Lieberman & Montgomery (1988) provided a unified framework and review of the research and concluded that first-mover advantages arise because of proficiency and luck. Theoretical models have confirmed that initial luck, skill-based or information asymmetries are prerequisites for gaining first-mover advantages. The concept of barriers-to-entry may also explain first-mover advantages, defining a barrier to entry as "a cost of producing which must be borne by a firm which seeks to enter an industry but is not borne by firms already in the industry (Von Weizsacker, 1980, p.400). First-mover advantages are normally more complex to gain and sustain than simply enter the market first. In recent years first-mover advantages have been reviewed by Ketchen et. al. (2004) as one research stream within competitive dynamics and Kerin et. al. (2001) have broadened the conceptual framework on first-mover advantages by analysing which mechanisms underlie these advantages and what factors have an enhancing or diminishing effect on the basic mechanisms. The mechanisms to gain and sustain first-mover advantages may be several, but here we discuss some key factors relevant for the development of markets for nature-based recreational goods.

Costs of entry are widely believed and found to be lower in service markets as compared to markets for manufactured goods (Song et. al., 1999) and services are often easier to copy than manufactured goods. These differences make it harder for a pioneer in services to gain and sustain a first-mover advantage compared to a manufactured good innovator. Moreover, due to the heterogenic characteristics of services it is easier for a later entrant to offer a slightly differentiated service directed at specific customer needs (Song et. al., 1999, 2000). Many potential recreational goods may very well resemble services in the sense that they are easily copied and that very little asymmetric information on product content can be established by the pioneer. On the other hand, if the recreational service supplied takes the form of an up-front investment in a recreational facility offered on a contract basis to user groups, then another type of mechanism may create and sustain first-mover advantages. This includes buyer switching costs, the possibility of affecting preferences, communication good effects and information and consumption experience asymmetries.

Buyer switching costs may arise quite strongly if the first-mover in some way manages to tie the buyers economically through a contract or through the buyers investing themselves in e.g. facilities established jointly with the first-mover agent. Thus, sunk costs on behalf of the buyers will make it more expensive for the follower to enter and compete with the first-mover. More standard buyer switching costs include the 'search and learning costs', which the buyer will have to sustain in order to investigate alternative services. Furthermore, the first-mover may also affect people's preferences by setting a standard, where new products and recreational goods marketed later will be compared to the first goods and its characteristics (Kerin et. al., 1992), and may be judged and valued according to the perceived 'ideal' combination of attributes (Chiang, 2004; Brekke, 1997). Buyer switching costs may be more important for recreational services that are partly intangible as their quality cannot be inspected by the user before purchase (Bharadwaj et. al., 1993).

A communication good effect may also arise for certain types of recreational goods if their value for the individual users increases as the number of users increase – at least to some level. An example is facilities directed towards social interaction among users, like mountain bike trails or role-play facilities. Users will be less willing to move their recreational activity to a new and less used facility, potentially creating the first-mover advantages (Carpenter & Nakamoto, 1989; Bahradwaj et. al., 1993).

### *2.3 Public procurement of environmental goods*

States and their public bodies ensure the provision of many goods. True public goods like defence and police are usually provided by public production, but often the production of goods, public or other, is delegated to private agents and the role of the public body becomes one of creating incentives for reaching the socially optimal supply. Such incentives often take the form of subsidies as when private landowners are partially compensated to supply environmental goods, or when general practitioners or dentists are subsidised to provide cheap health care.

How to undertake such public procurement efficiently have been analysed in numerous studies and with different approaches over the years. Since the seminal work of Akerlof (1970) such procurement problems have routinely been modelled as principal-agent problems, and the agency framework is now textbook material (e.g. Bolton and Dewatripont, 2005). Examples of applications concerning environmental services from agriculture and forestry include e.g. Hart and Latacz-Lohmann (2005), Anthon and Thorsen (2004) and Vedel et. al. (2006). Also auction theory (see Klemperer, 1999) has been investigated for public procurement schemes in this field, e.g. Latacz-Lohmann and Hamsvoort, (1997; 1998).

The analysis of this paper does not concern itself with asymmetric information, but it does concern itself with forthcoming information on market states, and is in that way related to Chatterjee and Sugita (1990). Furthermore, it concerns itself with the effects of fixed costs of production, here entry costs, and its role not only for the agents' entry decision, but also for the optimal design of procurement schemes over time. The role of fixed costs in procurement schemes have been investigated e.g., by Anthon et. al. (2007a, 2007b), who found rationing to be an optimal instrument for the social planner. The model of this paper differs in several ways, one of them being that it involves time dynamics and the revelation of forthcoming information. We point out that further analyses may identify circumstances where rationing is nevertheless optimal for the social planner.

## 3. Models

### *3.1 The entering game*

The decision problem of whether to enter a new market or wait is modelled by a non-cooperative Bayesian simultaneous-move game in two stages with strategic interaction between the players (Mas-Colell et. al., 1995).

We consider a simple model with only two agents, $i \in \{A; B\}$, and to begin we assume the agents are identical. The agents have the option to enter the new market by establishing and operating a new recreational facility to offer possible customers an improved recreational experience. However, each of them can at any time $t$ only offer the good in fixed quantities $q_{it} \in \{0; q_{At}; q_{Bt}\}$ and only after having incurred an initial investment cost which is $I_i$ for the firm that enters the new market and $bI_i$, with $b > 1$ for the firm that waits and enters the market second. Once the facility is established the agents may operate it at a cost $c$ proportional to the supply $q_{it}$, and sell the improved recreational experience on the market at a price, $p(Q_t; D^j)$, which depend on the aggregate supply across the agents $Q_t = \sum q_{it}$ as well as the state $j$ of demand $D^j$. As the market is new, demand is unknown to the agents, but they do hold expectations concerning its size. More specifically they expect demand to be low, medium or high, $D^j \in \{D^L; D^M; D^H\}$ with probabilities $l$, $m$ and $h = 1\text{-}l\text{-}m$. We assume that once an agent has entered the market, the state of demand, $D^j$, becomes immediately known to him, and furthermore becomes common knowledge after some time lapse, $T$. The discount rate is $r$.

Furthermore, the relation between demand, aggregate supply and profitability of establishing and running the facility is known by both agents to be:

- if demand turns out to be low it cannot sustain even one profitable project
- if demand turns out to be medium it can sustain only one project profitably – if both agents enter their overall returns will be negative
- if demand is high, both projects will be profitable

Thus, for a firm that decides to enter the market at first chance, $t = 0$, the expected present value, $V$, of the project is:

$$V(q_{it} \mid enter_{i0}) =$$
$$-I_i + E\left(\int_{t=0}^{T} e^{-rt}\left[p(Q_t; D^j) - c\right]q_{it}\,dt\right) + \frac{e^{-rT}}{r}E\left(\left[p(Q_t; D^j) - c\right]q_{it}\right).$$

(1)

Where the expectations operator, $E$, concerns the demand state, $D^j$. Note that here the entry decision is still assumed unconditional and hence the maximization concern the decision whether or not to operate, i.e. whether $q_{it}$ is 0 or not. This decision is conditional on the observed demand as well as on aggregate supply, $Q_t$, and hence the choice of the opponent. Note that if both firms enter immediately, $T = 0$. Also, any change in $Q_t$ for $t > T > 0$ will be due to the possible entrance of a competitor. Similarly, for the firm that decides to wait and enter only when demand is revealed to be high at time $T$, the expected present value at $t = 0$ is:

$$
\begin{aligned}
V(q_{it} \mid enter_{iT}) &= E\left( -e^{-rT} bI_i + \frac{e^{-rT}}{r}\left[p(Q_t; D^H) - c\right] q_{it} \right) \\
&= h \times \left( -e^{-rT} bI_i + \frac{e^{-rT}}{r}\left[p(Q_t; D^H) - c\right] q_{it} \right)
\end{aligned}
\qquad (2)
$$

Here the expectations operator concerns only the probability, $h$, that demand is high. Note that since the agent here needs to enter second he incurs a higher investment cost reflected in the factor $b$.

The equations (1) and (2) reveal that this problem is essentially a two period problem. One period prior to the market state becoming common knowledge and one period post revelation. Define the per period revenue function as $E\left(R_{it}^j(q_{it}; Q_t, D^j)\right) = E\left(\left[p(Q_t, D^j) - c\right] q_{it}\right)$. Furthermore, let:

$$
\begin{aligned}
K_1(T) &= \int_{t=0}^{T} e^{-rt} dt = \left( \frac{1 - e^{-rT}}{r} \right). \\
K_2(T) &= \int_{t=T}^{\infty} e^{-rt} dt = \frac{e^{-rT}}{r}.
\end{aligned}
\qquad (3)
$$

Suppressing the arguments of the functions, this allows us to rewrite equations (1) and (2) into:

$$
V(q_{it} \mid enter_{i0}) = -I_{i0} + K_1(T) \times E\left(R_{i1}^j(Q_1, D^j)\right) + K_2(T) \times E\left(R_{i2}^j(Q_2, D^j)\right) \qquad (4)
$$

$$
V(q_{it} \mid enter_{iT}) = h \times K_2(T)\left(-rbI_{iT} + R_{i2}^H(Q_2 \mid D^H)\right) \qquad (5)
$$

The equations clearly illustrate the dilemma, which drives the game to be analysed: Will the potential benefits of waiting, which essentially is the value of knowing the market state before investing, outweigh the potential benefits of entering quickly and maybe get a period of length T alone?

The dilemma is amplified by the fact that we assume the game to be a non-cooperative Bayesian simultaneous-move game, implying that the decision needs to be taken at each stage without knowing the opponent's decision at that stage. The pay-offs of each decision at each stage conditional on demand state and the opponent's decision are shown in a series of tables in the appendix. The results of the game theoretic analysis of this dilemma are presented in the next section, but before turning to them, we present the problem of the social planner.

### *3.2 The public procurement problem*

As explained above public procurement is usually directed towards the procurement of goods of a more or less public good nature. However, public subsidies for certain activities can also be socially optimal, e.g. dental expenses are in many countries at least partly subsidised and even private companies may obtain public support for risky innovation and R&D efforts if they would not otherwise be undertaken and is deemed of public interest. This latter case is the one most related to the case we investigate here.

The public procurement will only be relevant if no firms enter the market, and the social planner sees a welfare gain to be made from offering agents a subsidy large enough to have at least one of them entering the market. We model the subsidy as a one-time payment to the agent as an incentive to undertake the initial investment $I_{it}$. Given the above model for the private agents, the objective of the social planner is to choose the subsidy scheme, $s_{it} \in \{0; s_{A0}; s_{B0}; s_{AT}; s_{BT}\}$ (a contract defined by $\{s_{it}, q_i\}$ that maximizes social welfare. We let benefits be the integral of the demand schedule over $Q$, and subtract social costs:

$$W(s_{it};Q_t,D^j) = \max_{s_{tit}} K_1(T)E\left(\int_{Q=0}^{Q_1} D^j(Q)dQ - cQ_1\right) - \sum_{i=A}^{B} I_{i0} - \beta\sum_{i=A}^{B} s_{i0}$$

$$+K_2(T)E\left(\int_{Q=0}^{Q_2} D^j(Q)dQ - cQ_2\right) - rK_2(T)E\left([bI_{iT} + \beta s_{iT}] \mid D^j, s_{i0}\right)$$

(6)

We note that the subsidy is only a transfer and thus is not a social cost. However, public funds for such a transfer are usually financed by taxes and the social costs of levying such taxes are captured in the factor β. In Denmark, e.g. the Ministry of Finance assess that $\beta = 0.2$. We may separate the expected periodical consumer surplus, $E(CS(Q_t, D^j))$ (as a Marshallian measure) from the expected periodical producer surplus, $E(PS(Q_t, D^j)) = [P(Q_t, D^j) - c]\, Q_t$ when the investment has been established. This leads to (6) revised as:

$$W\left(s_{it};Q_t,D^j\right)=\max_{s_{tit}} K_1(T)\left[E\left(CS\left(Q_1,D^j\right)\right)+E\left(PS\left(Q_1,D^j\right)\right)\right]$$
$$-\sum_{i=A}^{B} I_{i0}-\beta\sum_{i=A}^{B} s_{i0}+K_2(T)E\left[E\left(CS\left(Q_2,D^j\right)\right)+E\left(PS\left(Q_2,D^j\right)\right)\right] \quad (7)$$
$$-rK_2(T)E\left(\left[bI_{iT}+\beta s_{iT}\right]\mid D^j,s_{i0}\right)$$

We assume that once decided upon, the social planner will announce and commit to the chosen plan for $s_{it} \in \{0; s_{A0}; s_{B0}; s_{AT}; s_{BT}\}$. Thus, no private information exist either concerning the actions of the social planner and hence the agents will simultaneously evaluate the offers made contingent on the declared plan for provisions of subsidies (contracts) and the resolution of the two-stage non-cooperative Bayesian simultaneous-move game.

# 4. Results

### *4.1 Analysing first-mover advantages with identical agents*

In Appendix 1 we have shown all the possible pay-offs for the agents, dependent on the three possible states of demand as well as the opponent's strategy. The overall expected return of any combination of strategies is the probability weighted sum of the returns from the three possible states of demand, cf. also (4) and (5). To save notation in the following, we denote the expected return conditional on the opponent's decision as $\pi(\text{decision}_A| \text{ decision}_B)$.

One can prove that the non-cooperative Bayesian simultaneous-move game has the following possible Nash Equilibriums (NE), depending on the parameters of the problem.

*Proposition 1:* Both entering at t = 0 will be the only NE iff
$\pi(\text{Enter}_A|\text{Enter}_B) > \pi(\text{Wait}_A|\text{Enter}_B)$.

*Proposition 2:* Both waiting forever will be the only NE iff
$0 > \pi(\text{Enter}_A|\text{Wait}_B)$.

*Proposition 3:* The mixed equilibriums, $\pi(\text{Wait}_A|\text{Enter}_B)$ and $\pi(\text{Enter}_A|\text{Wait}_B)$, will both be NE if $\pi(\text{Enter}_A|\text{Wait}_B) > 0$ and $\pi(\text{Wait}_A|\text{Enter}_B) > \pi(\text{Enter}_A|\text{Enter}_B)$.

We will not elaborate on the proofs here, but note that they make use of the fact that given the above model and assumptions we have $\pi(\text{Wait}_A|\text{Enter}_B) > 0$ and $\pi(\text{Enter}_A|\text{Wait}_B) > \pi(\text{Enter}_A|\text{Enter}_B)$. The general pattern of results is well-known for this type of games and is also found in e.g. Chatterjee and Sugita (1990). The models are different, and therefore also the exact parameters determining, which of the equilibriums is the relevant one.

Much of the literature on first-mover advantages has focused on what factors drive the value of the first-mover advantages and how they may be sustained, i.e. basically the NE's associated with the first and the last of the above three sets. Very little attention, however, has been given to the second possible NE, the scenario where none of the agents will be willing to move into the new market as the expected returns are negative. This scenario may be very likely in cases where entering implies relatively large up-front costs and the agents also face significant uncertainty regarding returns to investment, including potentially fast erosion of any first mover advantages. However, this scenario may be interesting from a social planner's point of view. It may be that even if entering the new market is not profitable for the private agent, the society at large may reap an overall welfare gain if the agent can be persuaded to enter. The conditions for this and the optimal design of persuading incentives are investigated next.

### *4.2 Solving for efficient public procurement*

With only two agents and essentially only two periods, the social planner faces a double question: How many agents does she need to offer a subsidy contract against the agent undertaking the investment $I_i$? And how small a subsidy is needed to bring about the optimal overall supply of the good? Because of the sequential game nature of the problem we analyse here, these two questions can only be resolved simultaneously. Given the set-up here with a two stage problem with two agents being able to supply only a fixed discrete quantity each, the social planner need not concern herself with how much she wants the individual agent to supply. It is either $q_{it}$ or nothing. She only has to consider how many of the agents to subsidise, when and how much. Regarding the first two questions, there are four possible decisions[32] embedded in (7) concerning the number of subsidies:

X: Only one subsidy is ever offered, and by the problem's construction this is offered at the beginning of period 1.

Y: The social planner offers a subsidy to both agents simultaneously, and by the problem's construction this is offered at the beginning of period 1.

Z: The social planner offers one subsidy in period 1, and only offers a subsidy in period 2, if the revealed demand suggests that there is a welfare economic gain to be made from improving it.

[32] Apart from the obvious and uninteresting case of not offering any contracts.

The latter question of 'how much' to offer each agent in the contract, is resolved by the maximization in (7) combined with the participation constraint implied by (1) and (2) modified with the subsidy offered in the contract. This allows us to evaluate the optimal level of $s_{it}$ in each of the four possible decisions and subsequently determine under which conditions, the different decisions may be optimal.

In Case X, when only one subsidy is offered, the constrained version of (7) is:

$$W\left(s_{i0};Q_t,D^j\right)=\max_{s_{it}} K_1(T)\left[E\left(CS\left(q_{i1},D^j\right)\right)+E\left(PS\left(q_{i1},D^j\right)\right)\right]-I_{i0}-\beta s_{i0} \\ +K_2(T)\left[E\left(CS\left(Q_2,D^j\right)\right)+E\left(PS\left(Q_2,D^j\right)\right)\right]-hrK_2(T)bI_{iT} \quad (8)$$

This reflects that only one agent will enter in period 1, and that the second agent will only enter in period 2 if the state of demand is high, which happens with probability $h$. To have an agent accept the contract offered, it must fulfil the incentive constraint:

$$V\left(q_{i1} \mid enter_{i0}\right)= \\ -I_{i0}+K_1(T)\times E\left(R_{i1}^j\left(q_{i1},D^j\right)\right)+K_2(T)\times E\left(R_{i2}^j\left(Q_2 \mid D^j\right)\right)+s_{i0}= \\ -I_{i0}+K_1(T)\times E\left(R_{i1}^j\left(q_{i1},D^j\right)\right)+ \\ K_2(T)\times\left(h\times R_{i2}^H\left(Q_2 \mid D^H\right)+m\times R_{i2}^M\left(q_{i2} \mid D^M\right)+l\times R_{i2}^L\left(q_{i2} \mid D^L\right)\right)+s_{i0}\geq 0 \quad (9)$$

That is, the subsidy must be large enough to at least keep the agent indifferent to entering or not. Note that the second stage term takes into account that the agent will be alone in period 1, but also potential entering of the second agent in period 2 (with probability $h$). This is reflected in the supply expected in the two periods. By the maximization in (8) it is straightforward that (9) will be a binding constraint.

For the case Y where the social planner offers both agents a contract simultaneously, the corresponding version of (7) is:

$$W\left(s_{i0};Q_t,D^j\right)= \\ \max_{s_{ti1}}\left(K_1(T)+K_2(T)\right)\left[E\left(CS\left(Q,D^j\right)\right)+E\left(PS\left(Q,D^j\right)\right)\right]-\sum_{i=A}^{B} I_{i0}-\beta\sum_{i=A}^{B} s_{i0} \quad (10)$$

This reflects that given subsidies, the quantity supplied will be constant and at maximum from the beginning. This also affects the subsidy needed, as it implies that none of the agents will enjoy a period alone on the market and that no matter what the state of the market is revealed to be, supply will be large and hence returns will be low. The incentive constraint becomes:

$$V\left(q_{i1} \mid enter_{i0}\right) = -I_{i0} + r^{-1} \times E\left(R_i^j\left(Q \mid D^j\right)\right) + s_{i0} = \\ -I_{i0} + r^{-1} \times \left[l \times R_i^L\left(Q \mid D^L\right) + m \times R_i^M\left(Q \mid D^M\right) + h \times R_i^H\left(Q \mid D^H\right)\right] + s_{i0} \geq 0 \quad (11)$$

It can be shown that the social planner in this case has to offer a larger subsidy than in the X-case, i.e. that (11)>(9). Whether it is, nevertheless, socially optimal to start both agents of right away depends on the welfare gain *W* in (10) relative to *W* of (8).

The final case we investigate, Z, is the one, where the social planner may consider offering a subsidy at time *T* too, i.e. once the state of demand is known. Note that we have assumed all along that the second agent will for sure enter if demand is high, and that at low demand market based income cannot even cover the costs of one agent. This leads to the logic conclusion that the social planner can only find it optimal to subsidise the second agent in case of a medium demand. Thus, the social welfare maximization problem becomes:

$$W\left(s_{it}; Q_t, D^j\right) = \\ \max_{s_{tit}} K_1(T)\left[E\left(CS\left(q_{i1}, D^j\right)\right) + E\left(PS\left(q_{i1}, D^j\right)\right)\right] - I_{i0} - \beta s_{i0} \\ + K_2(T)\left[E\left(CS\left(Q_2, D^j\right)\right) + E\left(PS\left(Q_2, D^j\right)\right)\right] \\ - rK_2(T)\left[m\left(bI_{iT} + \beta s_{iT}\right) + hbI_{iT}\right] \quad (12)$$

This is maximised by setting the smallest set of subsidies that satisfy the incentive constraints. For the first agent in stage 1, it needs to satisfy:

$$V\left(q_{i1} \mid enter_{i0}\right) = -I_{i0} + K_1(T) \times E\left(R_{i1}^j\left(q_{i1}, D^j\right)\right) + s_{i0} + \\ K_2(T) \times \left(h \times R_{i2}^H\left(Q_2 \mid D^H\right) + m \times R_{i2}^M\left(Q_2 \mid D^M\right) + l \times R_{i2}^L\left(q_{i2} \mid D^L\right)\right) \geq 0$$
(13)

Where the expectation concerning period two now includes both the probability that demand will be high and the second agent enter fore sure, and that demand will be medium and the second agent enter with a subsidy from the social planner. That subsidy will have to satisfy:

$$V\left(q_{i2} \mid enter_{iT}\right) = \\ -I_{iT} + r^{-1} \times \left(m \times R_{i2}^M\left(Q_2 \mid D^M\right) + h \times R_{i2}^H\left(Q_2 \mid D^H\right)\right) + s_{iT} \geq 0 \quad (14)$$

Which of the three subsidy schemes is the better, will not be developed further here. It will be determined by the size of *W* and the best size of subsidy by *V*. Thus the underlying first-mover game will play an important part in the social optimal subsidy scheme. Nevertheless, the results arrived at so far indicates that under some circumstances, it may be optimal to subsidize both agents immediately, e.g. to avoid a long period of low supply and that under other circumstances it will be optimal to ration subsidies over time to benefit from forthcoming information and hence offer only one subsidy first and only a second one if demand is favourable for this, but not high enough to secure entry of the second agent.

## 5. Discussion

Increasing rivalry in the use of nature areas for recreation implies that the forest as a site for recreational activity resemble more and more a common-pool good rather than a public good. At the same time, recreational activities have become more specialised and demanding, creating the possibilities for landowners to supply something extra in terms of facilities and services, which may allow for some degree of exclusion and hence marketability. This may be desirable from a socio-economic perspective because goods and services, which would not otherwise be supplied may suddenly be, maybe at the same time reducing rivalry for remaining nature areas. The entry into any market may be associated with first-mover advantages as well as risk and uncertainty. We argue that this may also be the case here.

The focal point in the literature on first-mover advantages has been gaining and sustaining first-mover advantages in emerging markets. In relation to nature-based recreational goods and services the development of new markets seems slow and patchy despite increasing demand from various user groups and potential first-mover advantages in this market.

Based on the special characteristics of nature-based recreational goods and services, we develop a model which encompasses the main problems: potentially high sunk costs, fixed supply, strategic interaction between a few agents in the potential market and uncertainty about the demand in the market. The model shows that in a case with no private information and identical agents all outcomes can be supported as NE of the Bayesian game, and thus situations of non-movers is possible depending on the relative importance of the different parameters. Specifically non-movers may be induced by a relatively large uncertainty of demand, resulting in advantages by letting others reveal the market. This value of waiting is well analysed in the real option literature (McDonald and Siegel, 1986) and has also been shown to affect policy measures like subsidies for entry (Thorsen, 1999), but what is important here is its relative size compared to the potential first-mover advantage.

However, the similarity between firms also rules out any scope for earning excess profits. As previously found in literature on first-mover advantages the possibility of excess profit will be ruled out because of competition when firms are identical (Liebermann & Montgomery, 1988). Whereas most analyses focus on the situations where one agent gains first-mover advantages for a shorter or longer while, we have focused on the situation of non-movers and possible scenarios of public procurement of nature-based recreational goods.

In a situation where a market does not develop by itself it may be relevant for a social planner to subsidise the market in the beginning in order to reveal the state of demand and promote market development. We calculate the expected welfare gains for a social planner under three different scenarios and derive the agents' participation constraints. The social planner can choose one of three scenarios: subsidise one agent at the beginning of period one, subsidise both agents at the beginning of period one or sequential rationing by subsidising one agent in period one and one agent in period two. Which subsidy strategy will be optimal for the social planner requires a deeper analysis which we have not dealt with in this paper but left for further work, but we expect to be able to identify under which circumstances, it may be optimal to subsidise both agents immediately and under which it will be optimal to ration subsidies over time to benefit from forthcoming information.

In the present model we have made several simplifying assumptions and one of the bolder one is that of identical agents. Further analyses should also look into the effect of differences among agents, e.g. what will be the effect of differences in the fixed quantity with which an agent will enter, what will be the effect of agent-specific differences in $T$, i.e. ability to cover-up information on the market state post-entry. Furthermore, while the sunk costs are quite essential and realistic for the model, we conjecture that we can relax the assumption of the agents' having a fully fixed supply post investment. A more realistic assumption would be that they may have a fixed maximum supply due to capacity constraints, but can in fact decide freely on their supply within this capacity. This would allow for improved monopoly rents for a first-mover and increase the social planner's incentive to support competitors' entry prior to market revelation.

## 6. Concluding Remarks

In this paper we have addressed the issue of first-movers, non-movers and social gains from developing a new market for nature-based recreational goods. We have addressed two main questions: i) Why is there a lack of market development? ii) Can there be social gains from intervention and supporting the development of such markets? and addressed more briefly iii) if so, then when and how should such intervention be performed best?

In order to answer the first question, we use a two-stage non-cooperative Bayesian simultaneous-move game model, and show that in spite of apparent potential first-mover advantages in this developing market, demand uncertainty and sunk costs may equally well result in widespread presence of non-movers on the supplier side. While most of the first-mover literature analyse the potentials for sustained first-mover gains, we have focused on the presence of non-movers.

Using a simple model, we answer the second question by showing that social gains can be made from offering a subsidy towards the sunk costs. Social gains may be made even in cases where a first-mover has already established it self. The third question, when and how such intervention should be done, is briefly illustrated by three subsidy schemes, i) only one subsidy is offered ever, ii) two subsidies are offered simultaneously, iii) one subsidy is offered and if revealed demand shows a welfare economic gain of offering another, this is done. Which of them is preferable will depend on revealed demand and the underlying first-mover game. This we will develop further in future work.

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## Appendix 1

**Pay-offs conditional on opponent behaviour and *high* state of demand**

| A\B | B waits at $t = 0$ | B enters at $t = 0$ |
|---|---|---|
| $A$ waits at $t = 0$ | 0, 0 | $K_2\left(-rbI_{iT} + R^H_{A2}(Q)\right)$, $-I_{B0} + K_1 R^H_{B1}(q_{B1}) + K_2 R^H_{B2}(Q)$ |
| A enters at $t = 0$ | $-I_{A0} + K_1 R^H_{A1}(q_{A1}) + K_2 R^H_{A2}(Q)$, $K_2\left(-rbI_{iT} + R^H_{B2}(Q)\right)$ | $-I_{i0} + r^{-1} R^H_i(Q)$ |

**Pay-offs conditional on opponent behaviour and *medium* state of demand**

| A\B | B waits at $t = 0$ | B enters at $t = 0$ |
|---|---|---|
| $A$ waits at $t = 0$ | 0, 0 | 0, $-I_{B0} + K_1 R^M_{B1}(q_{B1}) + K_2 R^M_{B2}(q_{B1})$ |
| A enters at $t = 0$ | $-I_{A0} + K_1 R^M_{A1}(q_{A1}) + K_2 R^M_{A2}(q_{A1})$,0 | $-I_i + r^{-1} R^M_i(Q)$ |

**Pay-offs conditional on opponent behaviour and *low* state of demand**

| A\B | B waits at $t = 0$ | B enters at $t = 0$ |
|---|---|---|
| $A$ waits at $t = 0$ | 0, 0 | 0, $-I_{B0} + K_1 R^L_{B1}(q_{B1}) + K_2 R^L_{B2}(q_{B1})$ |
| A enters at $t = 0$ | $-I_{A0} + K_1 R^L_{A1}(q_{A1}) + K_2 R^L_{A2}(q_{A1})$,0 | $-I_i + r^{-1} R^L_i(Q)$ |

# Using payments for environmental services to secure environmental services and livelihoods in coffee agroforests – A project portrayal

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## Abstract

An ongoing PhD project investigates the potential of Payments for Environmental Services (PES), one of the latest market based mechanisms for conservation of ecosystem services, to secure not only ecosystem or environmental services, but also the livelihoods of small scale farmers in Central America. This is done in the context of small holder coffee agroforestry systems in Costa Rica and Nicaragua, where vulnerability to coffee price fluctuations and uncertainties in the production are driving farmers towards more intensive cropping systems that do not provide nearly the same level of ecosystem services as shade coffee. The dismantling of the International Coffee Agreement in 1989 and price stabilization schemes (Costa Rica) left coffee farmers exposed to world price variability after a long period of relatively stable prices. This has had a profound impact on the vulnerability of coffee farmers' livelihoods and the ecological important shade coffee systems, as was witnessed during the coffee crisis in 2001/02. In both Nicaragua and Costa Rica certification schemes ensuring a minimum price or a price premium are widely adopted, but 'true' PES schemes involving direct payments based on provision of a certain environmental service from coffee agroforests are still in its infantry. PES schemes targeted at agroforestry systems, a label that also fits shade coffee systems, have been in work since 2003 in Costa Rica. In Nicaragua PES is being introduced in cocoa production systems that are similar to coffee systems in various ways. Furthermore, PES is being widely implemented in silvopastoral systems across the region. The organisation of coffee farmers in cooperatives dispersed throughout the coffee producing areas have a potential positive role in the facilitation of a PES scheme targeting small

holder coffee farmers. By drawing on PES experiences from other regions and sectors, and through an investigation of the livelihood strategies of coffee farmers and the role of cooperatives, the PhD project aims to formulate recommendations for the design of PES schemes that in an effective, efficient and equitable manner can sustain environmental services and improve livelihoods in the small holder coffee sector. The project is carried out in the collaborative auspices of CATIE in Costa Rica and University of Copenhagen, Denmark.

**Keywords**: Payments for environmental services, coffee, livelihood, PhD project, Central America.

## 1. Importance of small holder coffee systems

Coffee is a very important commodity in several Latin American countries, both ecologically and economically. It is often cultivated in biodiversity hotspots, where coffee agroforests[33]provide connectivity within degraded and fragmented forest, and facilitate movement and maintain viability of key wildlife populations (e.g. Messer et al, 2000; Beer et al, 1998). Shaded coffee systems are found in buffer zones of protected areas and inside the Mesoamerican Biological Corridor that all Central American countries are working together to develop and maintain (Pagiola & Ruthernberg, 2002; Kaiser, 2001). When located in watersheds that supply water to urban areas, coffee agroforests help to maintain the provision of clean water (Verbist et al, 2005). The ecological importance of coffee agroforests is matched by the socio-economic importance of the crop. In periods coffee is second only to oil in terms of commodity value on the international market (Ponte, 2002a). It is produced by more than 25 million farmers in 80 countries. 10 million small holder farmers depend on coffee as their primary source of income (Oxfam, 2001). In Central America coffee is planted on nearly 1 million ha and sustains the livelihood of 300.000 farmers (CIRAD, 2005). Small holder coffee farmers are often among the poorest segments of society in Latin America and depend on alternative products from the shade trees, e.g. medicinal plants, fire wood and timber (Gordon et al, 2007). However, when coffee prices or yields drop the shade tree products are not enough to sustain livelihoods.

[33] Coffee agroforests are often traditional coffee fields with diverse and multi-layered shade tree cover that serve the double role of reducing the need for inputs such as fertilizers, and provide alternative products such as fire wood, fibres, medicinal plants and other non timber forest products.

## 1.1 Fluctuating coffee prices

The International Coffee Agreement, an export quota system that involved both exporting and importing countries, was established in 1962 with the aim of stabilizing world coffee prices. In 1989 it collapsed after several countries withdrew from the agreement. One year later a World Bank report by Akiyama & Varangis (1990) described the agreement as at least partly successful, despite large fluctuations in the world price during the period. From 1961 to 1997 the coefficient of variation (CV) around the trend of Costa Rica's export price was 38 % and in recent decades the CV of average producer prices have been over 30 % and closely correlated with the world price (Hazell, 2000). In Nicaragua the situation is the same, though with general lower producer prices compared to Costa Rica (ICO, 2008). The dismantling of the ICA coupled with a considerable increase in the world coffee production during the 1990's led to general lower and continuously unstable world prices (World Bank, 2004; Varangis *et al*, 2003; Ponte, 2002b).

In 2001 the world coffee prices fell to the lowest real term level in 100 years, which marked the peak of the latest coffee crisis which adversely impacted the lives of hundreds of thousands of coffee producing families as well as the environment (Oxfam, 2001). In Mesoamerica alone an estimated 600.000 farmers and employees in the coffee industry lost their jobs[34] and thousands of Nicaraguan families left their coffee fields and lived under miserable conditions in the outskirts of urban areas. Rural emigration led to social unrest and increased crime rates in the areas receiving the immigrants, and the number of households living under the poverty-line increased. Many abandoned coffee agroforests were encroached and converted to intensively managed and short lived crops due to insecure tenure of the newcomers. Other coffee agroforests were converted to treeless pasture, intensively managed full-sun coffee or urban sprawl with resulting adverse effects on the environment (Bacon, 2005; Osorio, 2004; Gresser & Tickell, 2002).

The severe impact of a price fall on a single commodity indicates the significance of the crop and how vulnerable coffee farmers are to price falls. The shock effects of large decreases in prices emerge in the form of ruined lives and degraded environments, but the mere risk of price or yield decreases also affects small scale farmers who often do not have insurances

[34] Including Mexico, according to Rainforest Alliance. Other sources refer to other figures, e.g. 170.000 full time jobs in the five CA countries from Costa Rica to Guatemala (Varangis et al, 2002), 300.000 jobs in Mexico alone (Oxfam, 2002).

or other safety nets. Many farmers in both Nicaragua and Costa Rica have organized themselves in producer cooperatives that provide elements of risk pooling, e.g. through joint processing and marketing. Cooperatives are not effective when it comes to systemic risks, such as adverse weather and sudden commodity price falls (Varangis & Lewin, 2006), but they do offer certain elements of economies of scale and other advantages, e.g. joint purchase of better plant material, cooperative funds that pay for research and extension services, joint facilities for quality testing, and possibilities for Fair Trade certification and contracts with apex cooperatives that often pay half of purchased coffee up front at a predetermined price (Mosheim, 2002; Fontenay & Leung, 2002; own observations).

## 2. Payments for environmental services

Even though household incomes may be at a reasonable level for small holder farmers who produce coffee in agroforestry systems, the environmental services are not necessarily secured. In the last decade coffee farmers in Ecuador have been recommended to shift to other crops, as a result of low coffee prices and increasing demand for other crops. This has resulted in a decline of agroforestry systems in buffer zones around national parks, leaving the treeless agricultural frontier at the edge of the parks. Only recently have park authorities realized the adverse effects of the recommendations. A similar development is taking place in Costa Rica, where increasing prices on crops for biofuel are resulting in land use changes that favour intensive agricultural systems over agroforestry systems, including shade coffee (De Clerk, F., personal communication[35]).

There is a need to support the environmental services provided by agroforestry systems, such as shade coffee, as well as to reduce the income vulnerability of farmers and enhance their livelihoods. Payment for environmental services (PES) is a relatively new instrument in market based conservation that has attracted increasing attention for its ability to translate external, non-market values of the environment into real financial incentives for local actors to provide such services. Following the definition by Wunder (2005) PES schemes are voluntary transactions where a well-defined environmental service is being 'bought' by a service beneficiary from a service provider if and only if the provider can ensure provision of the service. Product based payments, such as premium prices for certified coffee, are sometimes included as a PES (Wunder, 2005). In the context of this PhD project certification schemes are not 'true' PES. The PES approach

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was originally conceptualized as a mechanism to improve the efficiency of natural resource management. However, in recent years PES has received increasing interest as a mechanism for simultaneous conservation of the environment and ecosystem services, development of rural areas and alleviation of poverty (e.g. Engel et al., 2008; USAID, 2007; Wunder, 2007). Indeed, as PES is based on the beneficiary-pays rather than on the polluter-pays principle, it is an attractive instrument in settings where providers of environmental services are poor, marginalized land-holders (Engel et al., 2008).

Costa Rica is a regional leader in the design of environmental programs and PES was written into the law in 1996 (Zbinden & Lee, 2005; Rojas & Aylward, 2003). It is one of the few countries where PES schemes are working, whereas other countries in the region, e.g. Nicaragua, seem to lack the legal and institutional settings to implement PES schemes effectively (Diaz & Jackman, 2007). Wunder (2007) mentions demand-side and supply-side problems; too few service users are convinced to pay and too little is known about what kind of resource-use incentives and institutional preconditions are needed. These are likely some of the main reasons why almost all PES schemes in developing countries are governed by central state authorities, as is the case in the government-led PES programmes in Costa Rica and Mexico (Pagiola, 2008; Muñoz-Piña et al., 2008). There are some examples of decentralized PES schemes, e.g. payments for watershed protection governed by municipalities in Ecuador, where water consumers pay farmers to protect a watershed (Wunder & Albán, 2008). Government authorities, central as well as non-central, are increasingly seeing PES as more efficient in reaching conservation goals than traditional command-and-control measures, because of the ability of PES to find and focus on higher-benefit cases with lower costs and the build-in feedback mechanism; service users have a strong incentive to ensure that their payments are used efficiently and if not they can request changes or stop the payments (Pagiola et al, 2004; Pagiola et al, 2002).

### 2.1 PES experiences

In Costa Rica the four categories of the PES programme; biodiversity conservation, carbon sequestration, watershed protection, and landscape beauty, are all targeted through payments for reforestation, forest protection and management, forest plantations, agroforestry systems and silvopastoral systems. An semi-autonomous agency, FONAFIFO, is managing the PES programme, though restricted by central government approval of all activities through budget approval and executive decrees that set the level and priorities of payments (Pagiola, 2008). Funds for payments are derived from different sources, e.g. the Global Environment Facilty, Conservation International, a 5 % fuel tax, and water users are increasingly paying for watershed protection through water levies. Thus, the PES programme is mainly a 'supply side' programme. Coffee agroforests are contained in payments for agroforestry systems, but currently payments are a one-time amount pr tree. It remains to be seen if coffee production under close canopies of remnant forest trees is eligible for payments under the forest management programme. Aspects of the silvopastoral programme, which is receiving much attention, may be relevant for PES in coffee agroforests.

In Nicaragua a coherent PES programme has been underway for some time, inspired by the programme in Costa Rica. A National Board on PES was created in 2003, but it has not yet been legally approved and due to collaboration problems with other government institutions, such as the Ministry of Environment, it is in reality not working (Díaz & Jackman, 2007). PES experiences in Nicaragua are limited to a few implemented PES schemes involving water protection and a range of schemes in the planning phase involving carbon trading and silvopastoral systems. However, though a coherent national effort seems to be wished for, many new initiatives are underway, e.g. PES targeted at cocoa producers in buffer zones of national parks (Jensen, L. B., personal communication[36]).

### 2.2 Paying for environmental services through coffee cooperatives

In order to secure environmental services in coffee agroforests, entice shifts from sun coffee to shade coffee production, and reduce farmers' vulnerability to price falls and losses in yield and enhance household livelihoods, it is necessary to develop PES schemes that target coffee agroforests. Payments should be open-ended and allowed to change as condition change, perhaps even vary in size depending on coffee producer prices, as opposed to the fixed one-time payment pr tree as it is working today in Costa Rica. However, if PES schemes are targeted at individual land users they may prove to be inefficient and ineffective, because of high transaction costs and small land holdings. Unlike the large coffee estates found in e.g. Brazil, small producers with small land holdings predominate in most of the coffee areas of Central America. As previously noted, small holder coffee farmers are often organized in coffee

[36] Former embassysecretary and in charge of the regional programme for environment, The Danish Embassy in Nicaragua, Managua.

cooperatives. There is a need to examine if targeting of PES schemes at such existing rural institutions would cater for higher efficiency and ease the implementation across many environmental service providers (Oberthur, T., personal communication[37]). It would ensure that environmental services are provided over a larger area and result in lower transaction costs for each member. However, often the poorest farmers are not in cooperatives and a sole focus on cooperatives for PES implementation risks a further marginalization of the poorest farmers. The project would benefit from attention given to this group in order to assess possible tradeoffs between PES efficiency and effect on poverty.

## 3. Project Objectives

Considering the socio-economic and ecological importance of shade coffee systems, there is a need for research on PES design that take into account the characteristics of shade coffee production and the risks that small holder coffee producers live with, both within and outside the institutional settings of cooperatives. The development objective of the project is to improve livelihood security of small holder coffee farmers through the development of PES schemes targeted at coffee producers and conditioned by a provision of environmental services from coffee agroforests. The **i**mmediate objectives are to assess livelihood strategies, with specific focus on land use decision making and risk management strategies, among small holder farmers in Costa Rica and Nicaragua and to investigate how direct payments to farmers conditioned by provision of certain environmental services influence livelihood strategies. Furthermore, to investigate how the institutional structure of coffee cooperatives in the same areas can facilitate PES implementation in small holder coffee agroforests based on the cooperatives' influence on cost and benefits of and incentives to engage in PES schemes. Finally, based on the analyses, to provide recommendations for design of PES schemes that target small holder coffee farmers with and without institutional association.

## 4. The PES frontier

PES as an instrument for environmental protection and poverty alleviation has been described quite voluminous in the last years, and especially within the last two years the number of scientific articles on different aspects of PES has increased substantially. In the peer-reviewed journal Ecological Economic two special editions on PES were published in

[37] Director of Markets for Ecoagriculture at Ecoagriculture Partners, Washington.

December 2007 and May 2008. However, detailed quantitative analysis of costs and benefits is poorly represented in the scientific literature and the most comprehensive review of PES initiatives is still the publication by Landell-Mill & Porras (2002), which covers 278 cases and concludes that the literature on environmental services fail to produce systematic analysis of the efficiency of emerging payment systems. As the interest of PES in poverty alleviation and rural development has increased, so has the number of studies concerning the dual objectives of service conservation and development. So far, published studies that show disproportionate benefits to larger and better-off landowners are more common than studies that show improved livelihoods of the poor, as outlined by Pagiola (2008). Besides conservation and poverty alleviation, recent PES publications deal with subjects such as PES design (Engel et al, 2008; Ferraro, 2008), decentralized PES (Wunder & Albán, 2008), spatial differentiation in the targeting of PES (Wünsher et al, 2008), impacts on land-use patterns (Koning et al, 2007), and organisational networks, access rights and equity (Cobera et al., 2007). No studies have been encountered that deal with PES and risk management. PES studies that include institutional aspects refer to a necessary 'de-bureaucratisation', promotion of organisational and community innovation and socio-institutional strengthening, but studies involving comparison of institutional settings among farmers in relation to implementation of PES are hard to come by (e.g. Grieg-Gran et al, 2005; Miranda et al, 2003). Many studies conclude that future research on differentiated and targeted PES schemes is needed (e.g. Pagiola, 2006; Wunder, 2006).

# 5. Project framework

## 5.1 Project components

The PhD project consists of three main components, of which two requires field work. Two potential locations for field work are currently being assessed; the Matagalpa region in Nicaragua, which is one of the main coffee producing areas in the country, and Turrialba in Costa Rica, where coffee also is grown extensively. The first two components of the project, as described in the following paragraphs, are linked with ongoing CATIE projects in these areas. Matagalpa, Nicaragua has partly been chosen for better integration of data and results with other projects in the region concerning research in institutional aspects of PES. The research and results from all components will to a large extent be valid for both countries as well as for Central America as a whole, though there is also a high potential for a comparisons of Costa Rica, a forerunner in PES, and Nicaragua, a PES 'beginner'. The three components are based on the following research questions:

1) What are the potentials of PES in reducing vulnerability to falls in coffee yields and prices, and improving the livelihoods of small holder coffee farmers in the Turrialba canton in Costa Rica?

2) How can coffee cooperatives in the Matagalpa region of Nicaragua facilitate the implementation of PES schemes that target coffee agroforests to become efficient, i.e. lower transaction costs; effective, i.e. involve large areas; and equitable, i.e. include many small holder farmers?

3) How can PES schemes targeted at small holder coffee farmers in and outside cooperatives be designed so that environmental services provided by coffee agroforests are conserved *and* the economic viability of small scale coffee agroforests is improved?

Research question 1 and 2 will be answered through extensive field work in Nicaragua and Costa Rica, where information on household characteristics of small holder coffee farmers based on household surveys, and institutional characteristics of coffee cooperatives will form the basis for analysis. Review of laws, decrees and regulations with relevance for PES, as well as interview with PES actors in both countries will also be used extensively. Experiences with PES in other crop systems, e.g. small scale cocoa production in Nicaragua and silvopstoral systems in the region, will be assessed in the context of the project. Field work will be carried out in spring 2009 an spring 2010. For further details on data requirements and data collection methods, see appendix a.

### 5.2 Theoretical background

The theoretical framework for the analysis will mainly consist of livelihood theory and economic theories. Livelihood theory evolves around livelihood strategies which encompass issues such as household risk strategies, household coping strategies, income-activity diversification, rural poverty, intra-household relations, rural growth linkages, rural non-farm activities, and rural-urban migration (Barret et al, 2001; Rakodi, 1999; Ellis, 1998). Economic theories are divided into a range of subfields, of which environmental policy (Baumol & Oates, 1988) and ecological economics

(Daly & Farley, 2003) are of special interest and both encompass market based conservation and incentive based natural resource management.

Another theory of relevance to the project is institutional theory on collective action and transaction costs (Ostrom, 1998; North, 1990). While Ostrom focus on institutions vis-à-vis collective action and social dilemmas dealt with through reciprocity, norms, rules etc., North's theory of institutions is a combination of theories of human behaviour, transaction costs, and production. Both are relevant for the role of cooperatives in efficient implementation of PES.

### 5.3 Research partners

The project has been developed in collaboration with the leading PES institution in Central America, CATIE[38] and staff at Forest & Landscape, University of Copenhagen. The project is closely linked to research activities at both research institutions, among these the EU funded CAFNET[39] project, which also involves the international organization Ecoagriculture Partners who work with the development of markets for ecoagriculture, a label that also fits shade coffee systems. The work in Nicaragua and Costa Rica will be carried out in collaboration with staff from CATIE. The Field work is funded by the Danish Development Assistance (DANIDA) and will partly be carried out in collaboration with other DANIDA funded projects involved in the development of market based conservation tools.

## 6. Main outputs

At least four articles will be submitted to international peer-reviewed journals. The case studies and results will be presented at relevant forums, mainly at the two collaborating research institutions.

*Tentative list of papers:*

1) Paper 1: Livelihood strategies among small holder coffee farmers and risk management in relation to uncertainties in yield and prices.

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[38] Tropical Agricultural Research and Higher Education Centre.

[39] Connecting, enhancing and sustaining environmental services and market values of coffee agroforestry in Central America, East Africa and India. A partnership project under the EU Programme on Environment in Developing Countries between CIRAD; University of Wales; Bangalore University; CATIE; Coffee Board of India; and ICRAF.

2) Paper 2: The potentials of PES to enhance livelihoods of small holder coffee farmers and secure and increase environmental services in coffee agroforests.
3) Paper 3: Making PES efficient, effective and equitable - the role of coffee cooperatives in provision of environmental services.
4) Paper 4: Recommendations for design of PES schemes targeting small holder coffee farmers in and outside cooperatives.

The project investigates both sides of PES; the market based approach to conservation of environmental services for which PES was originally conceptualized, and the potential of using at least partly market based mechanisms to alleviate economic hardship among small holder coffee producers. Therefore, an important output of the project is a number of policy briefs, based on the scientific articles, which describe recommendations for design of PES schemes that target small scale coffee agroforests with the two-legged goal of conserving environmental services and improving farmers' livelihoods centred on coffee production.

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# Annex A:
# Project Framework

| | | |
|---|---|---|
| **Methods** | Household survey of PES farmers and non-PES farmers<br>Asset and farm survey | Household survey<br>Semi-structured interviews |
| **Data required** | Household characteristics, income generating activities, crop types, farm size, assets… | The view and perception of farmer |
| **Operational questions** | What are the livelihood strategies among coffee farmers in the study area, in terms of alternative crop selection, income activities, and savings and loans? | What are the farmers' perceptions of risk? |
| **Research questions** | What are the potentials of PES in reducing vulnerability to falls in coffee yields and prices, and improving the livelihoods of small holder coffee farmers in the Turrialba canton in Costa Rica? | |
| **Immediate objectives** | Investigate the potential of PES to improve livelihoods among small holder coffee farmers | |

| | | |
|---|---|---|
| Production record review, household survey | Household survey, production records, semi-structured interviews, follow up interviews, | Interview with FONAFIFO, review of existing agreements, interview with providers and beneficiaries (other systems), |
| Income from coffee, total household income | Historic coffee prices, yield records, coffee and total income, savings, | Payment size, frequency, period, who pays, open-ended, changeability, monitoring systems, conditionalities, fund management – from different PES schemes |
| How large a share of the household income comes from coffee production? | To what extent are farmers vulnerable to coffee price fluctuations and reduced yields? | What characterizes payments for environmental services in PES programs in which coffee agroforests are potential service providers? |
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|---|---|---|
| Review of existing agreements, production and income records, visit to FONAFIFO, review of PES programmes, household survey | Household survey, interviews with farmers, review of agreements, secondary data from CATIE projects | Review of literature on land use systems, FONAFIFO, review of PES agreements |
| Size of payments in different PES programmes, income from coffee production, potential sources of funds | Coffee production system characteristics, | Characteristics of ES and alternative land use systems |
| What is the potential size of PES compared to income from coffee? | Which ES are or can be paid for in coffee agroforests? | Can provision of ES be continued in other land use systems? |
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|---|---|---|---|
| Review of PES agreement, household survey, interviews with farmers, review of experiences from other agricultural systems, secondary data from CATIE | Household survey, interviews with farmers, PES agreement review | Review of PES laws, visit to PASOLAC office, | Interview with cooperative management and members, PASOLAC, review of PES agreements |
| Transaction costs, fixed costs, PES agreement specifics, livelihood strategy | Use of products from trees, farmers perception, PES specifics | Agroforestry systems contained in the PES programme today | Transaction costs, fixed costs, payment size, production constraints, |
| What are the potential costs of PES participation in terms of constraints on production and livelihood? | How do farmers themselves benefit from ES and are these benefits in conflict with potential PES? | What types of agroforestry systems are receiving PES today? (also relevant for the first research question) | What are the potential costs and benefits to cooperative members of participating in PES schemes? |
| | | How can coffee cooperatives in the Matagalpa region of Nicaragua facilitate the implementation of PES schemes that target coffee agroforests to become *efficient*, i.e. lower transaction costs; *effective*, i.e. involve large areas; and *equitable*, i.e. include many small holder farmers? | |
| | | Examine the role of cooperatives in efficient, effective and equitable PES schemes | |

| | | | |
|---|---|---|---|
| Review of PES agreements, interview with cooperatives (cocoa), | Review of PES agreements, review of PES system, PASOLAC, interview with PES actors | Interviews with farmers and cooperative management, review of membership contracts | Interviews with farmers and cooperative management, |
| PES agreement specifics, cost of PES in cooperatives and for private farmers | PES system characteristics, application procedures, | Cooperatives' institutional characteristics, membership contracts, farmers' view on coop, | Cooperative rules, farmer-cooperative contract specifics |
| What is the cost (benefit) reduction of PES through cooperatives compared to PES to single farmers? | How are PES agreements implemented and on whose incentive? | Other than economic considerations, how can cooperative membership influence farmers' incentive to engage in PES schemes? | What mechanisms and tools are available to cooperatives in ensuring continuous commitment to PES schemes among cooperative members? |
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<tr>
<td>Household survey of coffee farmers in cooperatives<br>Farm and asset assessment</td>
<td rowspan="5">Policy implications:<br>Recommendations for design of PES schemes that target small holder coffee producers in and outside producer cooperatives. Based on the following research question:<br>How can PES schemes targeted at small holder coffee farmers in and outside cooperatives be designed so that environmental services provided by coffee agroforests are conserved and the economic viability of small scale coffee agroforests is improved?<br>It will be based on a synthesis of the results and data from the first two components.</td>
<td rowspan="5">Project assumptions:<br>1) Experiences from cocoa production and silvopastoral systems and other agroforestry systems may be transferred to the case of coffee agroforests.<br>2) Coffee agroforests are providing some sort of environmental service, e.g. biodiversity conservation, carbon sink, water catchment protection or landscape values.<br>3) Coffee producing areas are located in buffer zones, biological corridors, or other ecological important areas.</td>
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<td>Income level<br>Assets<br>Farm size<br>Income activities</td>
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<td>What is the household level, in terms of income and assets, of cooperative farmers?</td>
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# A theoretical analysis of illegal wood harvesting as predation – with two Ugandan illustrations

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## Abstract

By assuming a forest growing logistically and a local population that harvests wood illegally in a manner similar to predation, a bio-economic model gives the following results: 1) when local population is very low, optimal deterring effort is zero; 2) as long as the population is sufficiently low, no deterring effort is required to avoid complete deforestation; 3) when population is above minimum threshold, optimal deterring effort is determined by the cost of deterrence relative to the value of wood; 4) when human population grows above a higher threshold, deterring effort must be greater than zero to avoid complete deforestation; 5) the larger the population grows, minimum deterring effort to avoid exhaustion approaches maximum effort; 6) when human population is very large, the relative cost of deterrence must be low, or the price of wood very high, to make deterrence worth wile.

**Keywords:** bio-economics, deterrence, forest management, ownership.

## Introduction

Forests in many parts of the world, particularly those in the developing countries, are exploited with little control by the owner, which may be the state, a co-operative, a private enterprise, or an individual person. In some instances wood is harvested in spite of serious attempts by the owner to deter illegal activities. Authorities like the public forest service or police may be involved in harvest control. Just as often, however, the formal owner does not take measures to reduce illegal harvesting in spite of knowing well what goes on. This is often the case in large parts of Sub-Saharan Africa. To some observers the little effort in deterrence on part of the owner seems incomprehensive, or at least less than optimal (Poore 1989).

In cases of illegal harvesting of valuable timber with a well defined owner who tries to deter illegal operations, one may analyse the behaviour of illegal operators as well as owners or authorities in terms of avoidance costs, probability of detection, level of fines, and the cost of patrolling (Milliman 1986, Clarke et al. 1993, Amacher et al. 2004). This type of activity is quite similar to theft. Normative economics may then be used to study optimal behaviour of both the thief and the police.

In the following a slightly different situation is analysed. Consider a fairly large tract of forest or woodland which is state owned and under public management. A local population lives in or near the forest, and they use wood both for own consumption and sale. The public manager of the forest imposes some regulations requiring wood harvesting to be licensed. Licenses are only sold for a limited volume of wood in each time period. These measures are taken to achieve sustainable harvest rates, and are imposed in accordance with democratically determined rules and procedures. Many people harvest wood in this forest without a licence in spite of the regulation, and this is well known to the manager. This illegal harvest leads to degradation of forest vegetation. The manager, however, does not spend much effort in deterring people from illegal exploitation. The objective here is to analyse the behaviour of the manager of such a forest, and to make some general recommendations on the optimal level of deterring effort.

## Model

Optimal management of illegal harvest is analysed by use of a bio-economic model (Beltrami 1993). Assume for simplicity that volume of wood in the forest grows logistically:

$$F(x) = rx\,(1 - x/K), \tag{1}$$

where $x$ is the stock of wood, $F(x)$ is increment, $r$ is the intrinsic growth rate, and $K$ is the forest carrying capacity of land. Depensation may occur, but this complication is not considered here. However, there is no reason to believe that we have a growth function with critical depensation (Stigter & van Langevelde 2004) as long as we deal with common woodland trees.

In the absence of regulation, the local population harvests wood like predators:

$$h = \alpha x n, \tag{2}$$

where $h$ is volume of harvested wood, α is the predation coefficient, and $n$ is the number of local people using the forest. It is reasonable to assume increasing harvest with both availability – stock – of wood, and number of people in or around the forest. The latter is particularly realistic as long as wood harvesting is for subsistence or for additional income generation among peasants. If wood exploitation becomes the main economic undertaking of a few entrepreneurs, the relationship between harvest level and population is better modelled as an ordinary commodity market. One may, even in our case, assume a saturation level of wood consumption among local people. If so, a multiplicative equation with a constant predation coefficient, as in (2), overestimates harvest at large stocks.

Size of local population does not depend on wood harvest, but is an exogenous variable related to profitability of agriculture and alternate employment opportunities in other (urban) sectors.

The authorities prohibit wood harvesting[40], and undertake patrolling activities to deter people from (illegal) harvesting. The volume of deterred wood harvest is a function of the authorities' effort and the total volume of illegal harvest:

$$a = \beta E h, \quad (3)$$

where $a$ is the volume of deterred wood harvest, β is the "catchability" of illegal wood harvesting, and $E$ is the deterring effort. Catchability depends on the structure of the forest (closed, open) as well as the type of produce extracted, e.g. logs, firewood, charcoal. Catchability may be affected by the behaviour of loggers, but this feed-back is not considered further here.

If deterrence is undertaken by the authorities, the extracted quantity, $h_d$, is given by:

$$h_d = h - a = \alpha x n\,(1 - \beta E). \quad (4)$$

The intuitive understanding of (4) is that the predation coefficient is reduced from α to α (1 - β$E$) as a result of deterring effort on part of the authorities[41].

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[40] This may also include harvest regulation by licenses or quota, but the discussion is simplified without much loss of understanding by concentrating on full prohibition.

[41] If deterring effort has a diminishing marginal effect on the predation coefficient, $h_d$ could be expressed as $\alpha xn(1-\beta E^{\gamma})$, $0 < \gamma < 1$. This would imply that higher efforts are optimal than in the above case, but the fundamental behaviour of the model would not change.

The rate of change in resource stock can then be expressed as:

$$dx/dt = F(x) - h_d = rx\,(1 - x/K) - \alpha xn\,(1 - \beta E), \qquad (5)$$

where $h_d$ is extracted quantity when the authorities act to deter illegal harvest.

For a given effort, $\overline{E}$, steady state is characterised by increment being equal to harvest:

$$F(x) = h_d \Rightarrow 1 - \frac{x}{K} = \frac{\alpha}{r} n(1 - \beta\overline{E}),$$

which means that the equilibrium stock of wood is given as:

$$x^* = K\left(1 - \frac{\alpha \cdot n}{r}(1 - \beta\overline{E})\right).$$

Harvested volume of wood in equilibrium, $h_d^*(E)$, is then given as:

$$h_d^*(E) = \alpha\, nK(1 - \beta E)\left(1 - \frac{\alpha\, n}{r}(1 - \beta E)\right).$$

(6)

The authorities' objective is to maximize social welfare in the long-run. For situations of equilibrium this implies the maximisation of the surplus, $S$:

$$S = p_x\, h_d^*(E) - cE\,,$$

(7)

where, $p_x$ is the net price of standing wood, and $c$ is the unit cost of controlling effort. If $h_d$ is not large enough to affect price, $p_x$ is constant[42], and the necessary condition for maximisation is

$$dh_d/dE = c/p_x.$$

## Results

[42] Some price-demand relationships are explored in the Appendix.

In line with general resource economics (Clark 1990), one may notice that if effort costs something, maximum social surplus is always achieved at less than maximum sustainable yield, and less than maximum effort.

The derivative of $h_d*(E)$ is

$$\frac{dh_d*}{dE} = \alpha nK\left[\frac{2\alpha n\beta}{r} - \frac{2\alpha n\beta^2}{r}E - \beta\right],$$

which is zero for

$$E = \frac{1}{\beta} - \frac{r}{2\alpha n\beta}.$$

This means that both $dh_d/dE = 0$ and $E = 0$ when $n = r/2\alpha$. When $n < r/2\alpha$, $dh_d/dE = 0$ for $E < 0$, which is impossible in practice. What this implies is that maximum social surplus is achieved at zero deterring effort whenever $n < r/2\alpha$ because the $h_d*(E)$ curve is strictly falling for positive and increasing $E$. This seems reasonable since small populations will harvest little wood, higher increment rates require lesser deterring effort, and a high predation coefficient requires more effort.

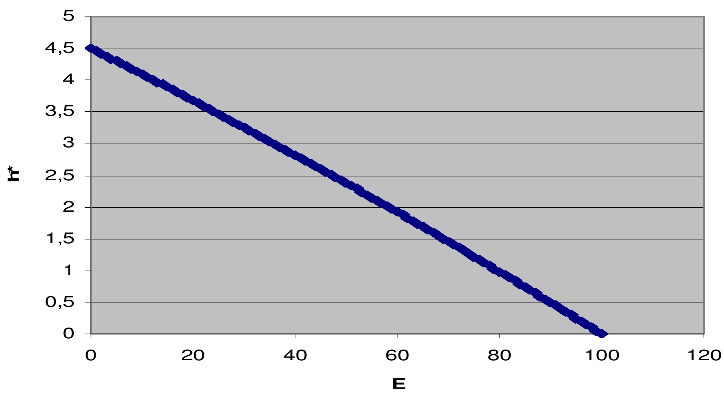


**Figure 1**. The relationship between deterring effort and equilibrium harvest when human population is very small. (Parameters used: $r = 0.5$, $K = 100$, $\alpha = \beta = 0.01$, $n = 5$, and $E = 75$).

It is also interesting to note that $h_d*(E) = 0$ at the following points: $E_{max} = 1/\beta$ and $E_{min} = \frac{1}{\beta}\left(1 - \frac{r}{\alpha n}\right)$. $E_{max}$ is maximum effort which stops harvesting completely and keeps forest density at carrying capacity. On the other hand, $E_{min}$ is the minimum deterring effort that results in open access and complete deforestation. When $n < r/\alpha$, $E_{min}$ is less than zero, complete deforestation is impossible even at no deterring effort. When n > $r/\alpha$, $E_{min}$ > 0, deterring effort must be greater than zero to avoid complete exhaustion of wood resources in the forest. As human population grows, the deterring effort necessary to avoid complete deforestation approaches maximum effort at $E_{max} = 1/\beta$.

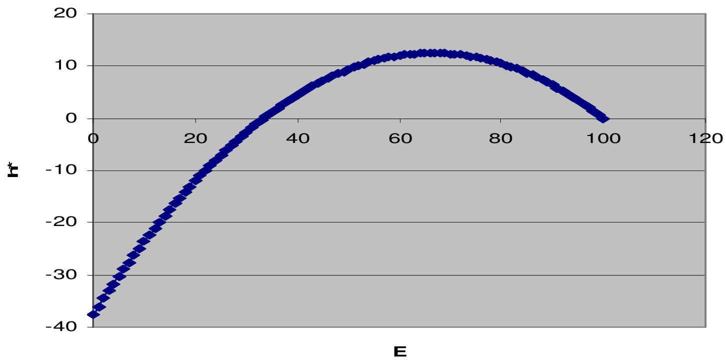


**Figure 2**. The relationship between deterring effort and equilibrium harvest when human population is large.
(All parameters as in Fig.1, except $n = 75$).

Conclusions:

1. When local population is very low, $n < r/2\alpha$, in relation to forest increment and the predation coefficient, optimal deterring effort is zero (Fig.1).
2. As long as the population is sufficiently low, $n < r/\alpha$, no deterring effort is required to avoid complete deforestation.
3. When population is above minimum threshold, $n = r/2\alpha$, optimal deterring effort is determined by the cost of deterrence relative to the value of wood, $dh_d/dE = c/p_x$. The more expensive deterrence is, less effort is optimal. The more valuable the wood is, more effort is optimal.
4. When human population grows above a higher threshold, $n < r/\alpha$, deterring effort must be greater than zero in order to avoid complete deforestation (Fig.2).
5. The larger the population grows, minimum deterring effort to avoid exhaustion approaches maximum effort determined by "catchability", $E_{max} = 1/\beta$.

6. When human population is very large, the relative cost of deterrence must be low, or the price of wood very high, in order to make deterrence worth wile, thereby avoiding complete deforestation.

## Two numerical examples from Uganda

To illustrate how this analysis may explain the different levels of effort in harvest control, or even advice owners and authorities on the optimal level of such effort, two examples are constructed based on parameter values that are broadly consistent with empirical evidence from Uganda.

***Open woodland***

Consider 1500 ha of woodland (Namaalwa et al. 2007) now stocked with an average of 40 tons $ha^{-1}$, which means that growing stock, $x$, is 60,000 tons. We assume the parameters of the logistic growth function to be; $r = 0.04$ and $K = 150$ [tons $ha^{-1}$] $\cdot 1500$ [ha] = 225,000 [tons]. 2,000 people live in the villages using this woodland. If these people harvest approximately 1 ton per capita per year now, we may estimate the predation coefficient, $\alpha$, from (2) as follows: $h = 2\ 10^3$ [tons $year^{-1}$] $= \alpha \cdot 60\ 10^3$ [tons] $\cdot\ 2\ 10^3$ [people] $\Rightarrow \alpha = 1.67 \cdot 10^{-5}$ [tons $cap^{-1}$ $year^{-1}$].

If we measure deterring effort in manyears, and apply a cost of \$ 1 per day, we have an estimate of $c = 250$ \$ $manyear^{-1}$. Assuming that one manyear is spent on deterring illegal harvesting from this woodland area, and that this reduces actual harvest by 10 %, catchability, $\beta$, is 0.1. We estimate a value of 2 \$ $ton^{-1}$ of woody biomass, based on a roadside price of \$ 1 per bag (50 kg) of charcoal, a burning efficiency of 15 %, and an insignificant cost of labour.

Because there are many people using the resource, and the predation coefficient is relatively high compared to the biological yield of this woodland, equilibrium stock for zero deterring effort will be quite low (37,000 tons). Although there is no danger of complete exhaustion of the resource, a few guards patrolling the woodland would reduce the predation coefficient and thereby increase biomass density so that the total quantity harvested could be maintained at a higher level. Four guards would result in an equilibrium stock of 112,000 tons, and an annual harvest of 2,250 tons. Since there is a cost of deterring effort, however, the optimal effort is slightly lower, i.e. three guards as shown in Fig.3.

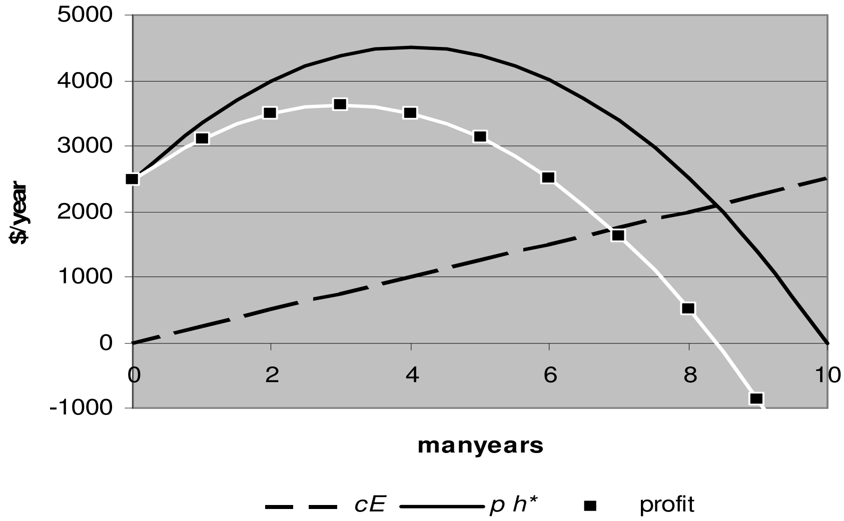


**Figure 3.** Income, expenses and profits in equilibrium determined by varying deterring effort. In this woodland example 3 man-years is optimal effort.

***Charcoal***

Consider a woodland area (Namaalwa et al. 2008) of 1.2 $10^6$ ha in central Uganda supplying the 2 $10^6$ inhabitants of Kampala with charcoal. The urban population consumes 0.18 tons cap$^{-1}$ of charcoal annually, i.e. a total of 360 $10^3$ tons year$^{-1}$. Charcoal is produced from woody biomass at an efficiency of 17 percent. The annual consumption of charcoal, therefore, corresponds to an annual harvest of 2.1 $10^6$ tons of woody biomass. Average biomass density in the woodland is 30 tons ha$^{-1}$. This means that growing stock, $x$, is 36 $10^6$ tons. We assume the parameters of the logistic growth function to be; $r$ = 0.04 and $K$ = 150 [tons ha$^{-1}$] ·1.2 $10^6$ [ha] = 180 $10^6$ [tons].

We may estimate the predation coefficient, $\alpha$, from (2) as follows: $h$ = 2.1 $10^6$ [tons year$^{-1}$] = $\alpha \cdot 36\ 10^6$ [tons] $\cdot$ 2 $10^6$ [people] $\Rightarrow \alpha = 2.9 \cdot 10^{-8}$ [tons cap$^{-1}$ year$^{-1}$].

Deterring effort is measured in man-years as before, and we assume a cost of \$ 2 per day, which means that $c$ = 500 \$ manyear$^{-1}$. Assuming that 200 man-years are spent on deterring illegal harvesting from this woodland area, and that this reduces actual harvest by 1 %, from (3) we find that catchability, $\beta$, is 0.5 $10^{-3}$.

We estimate a value of 2 \$ ton$^{-1}$ of woody biomass at present demand, based on a roadside price of \$ 1 per bag (50 kg) of charcoal. In this example, however, where we examine the whole supply of charcoal for Kampala it is reasonable to assume there is a functional relationship between harvested quantity and price. The elasticity, $\eta$, has been set at 1.5, while the parameter $D = 5\ 10^9$. This results in a demand curve as shown in Fig.4.

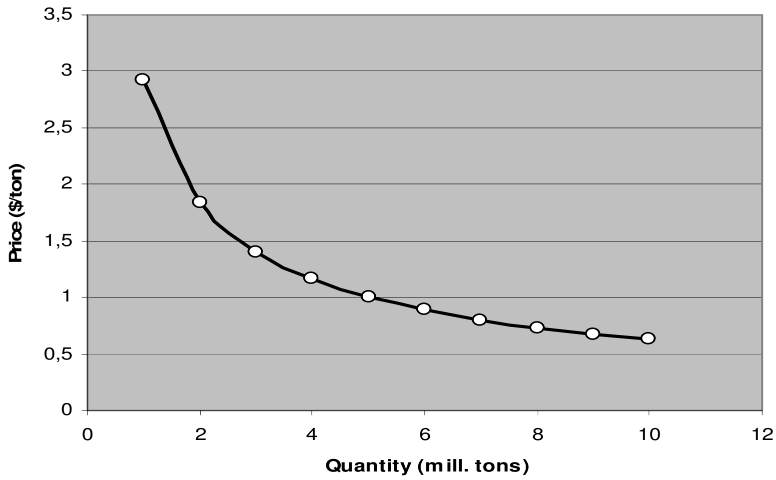


**Figure 4.** Demand curve for biomass in charcoal production for Kampala

Fig.5 shows the equilibrium harvest as a function of deterring effort. If the annual effort is below 621 manyears, the forest will be depleted.

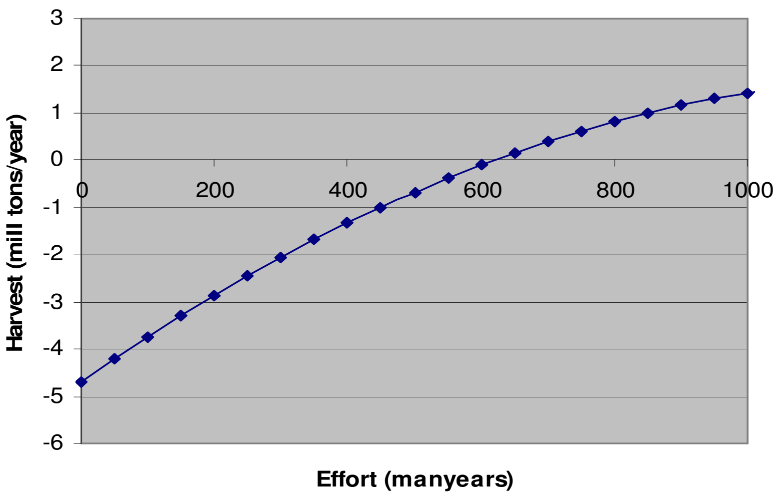


**Figure 5.** Equilibrium harvest as a function of deterring effort

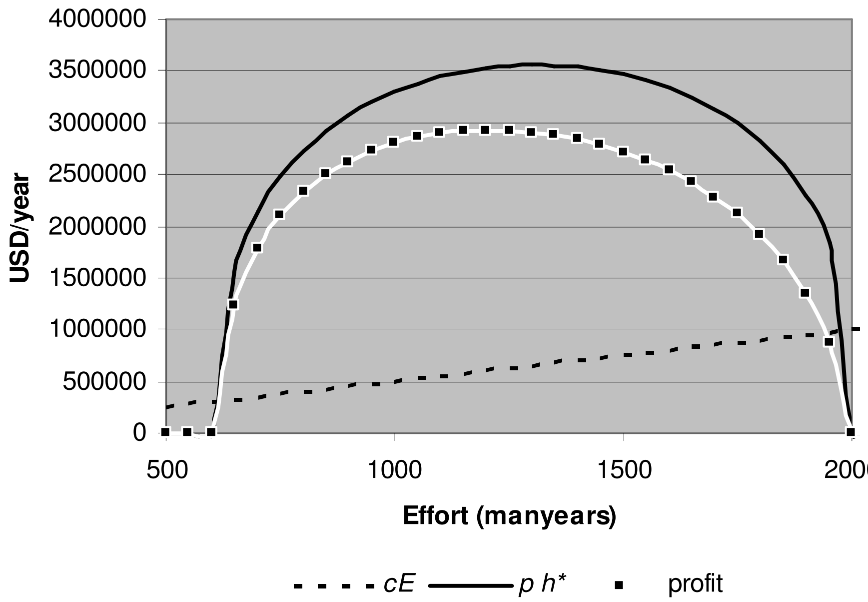


**Figure 6.** Economics of deterrence. *cE* is cost of deterrence, *ph** is net price times harvested quantity, and profit is the difference between the two.

Fig.6 illustrates the economics of deterrence. It shows that optimal effort is approximately 1200 manyears year$^{-1}$.

The population of Kampala grows by more than 3 % p.a. In spite of many initiatives to introduce more efficient charcoal stoves, most people continue using traditional stoves for cooking. Electricity, gas and kerosene are substitutes for charcoal, but under present conditions there is little reduction in per capita charcoal consumption. The price of charcoal has not increased substantially (in real terms, i.e. corrected for inflation) during the last 10 years (Hofstad and Sankhayan 1999), however. On this background one may expect harvested biomass to increase for quite some years to come. Even though the above mentioned factors may reduce the predation coefficient over time, population growth will probably outpace substitution effects. Therefore, it is likely that the optimal deterring effort will increase over time also.

## Limitations

The analysis has not considered the case where standing forest has a value (Hartman 1976). It is obvious that many tropical forests and woodlands have a value while standing, and not only after felling for firewood, charcoal or timber. The value of standing forests in the tropics may be related to erosion control, stability of water flows, or maintenance of bio-diversity and carbon stocks. The value of standing forests varies considerably depending on the specific ecological characteristics of the site and vegetation in question. As an example; open woodland in Sub-Saharan Africa on land that is not prone to soil erosion may not be very valuable in environmental terms, while the main value of such vegetation lies in its potential to produce wood. Therefore, the above analysis may capture the main concerns of forest managers and policy makers in some cases, but it is not difficult imagining situations where a broader analysis is warranted.

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## Appendix

In many cases $h_d$ is large enough to affect price, i.e. $p_x = p(h_d)$. Elasticity of demand, $\eta$, is defined as:

$$\eta = -\frac{dh_d}{dp_x}\frac{p_x}{h_d}.$$

A suitable demand function would be: $h_d = D\, p_x^{-\eta}$, where $D$ is a constant. In case of unit elasticity $h_d = D/p_x$, or $p_x = D/h_d$. The social objective is the same as before, and equation (7) is still valid:

$$S = p_x\, h_d^*(E) - cE\ ,$$

where, $p_x$ is the net price of standing wood, and $c$ is the unit cost of controlling effort. In the case of unit elasticity, equation (7) can be written as

$$S = D - cE.$$

Then the optimal policy is not to engage in deterring activities at all. If $c$ is positive, $S$ is maximised when $E = 0$.

If $\eta \neq 1$, equation (7) becomes

$$S = h_d^*(E)\sqrt[\eta]{\frac{D}{h_d^*(E)}} - cE\ .$$

In this case the magnitude of $D$ is important for deciding whether deterrence makes economic sense. Except for that, the conclusions are quite similar to those found in the case of constant price.

# Implications of EU renewable energy policy for wood use in Europe

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## Abstract

The European Union is aiming to substantially increase the use of renewable energy. In 2007, the EU set a target of 20 % of the overall energy consumption should be derived from renewable sources by 2020. National targets based on this figure were agreed upon at the beginning of this year. As wood is currently the most important source for renewable energy, the new targets can be expected to have strong implications for wood use in Europe. In this paper, the current situation of both the material use and energy use of wood is considered, as well as the possible impacts of increased utilization of wood energy on European wood demand. The situation is analyzed from the perspective of 29 European countries as well as from the specific viewpoint of Finland and Sweden. The study shows that the availability of wood for both material and energy use will prove a major challenge for the EU if its energy targets are to be met primarily by wood.

**Keywords:** Wood use, wood supply, wood energy, wood resource balance, energy policy, renewable energy

## Introduction

In the Kyoto Protocol many developed countries committed themselves to reduce greenhouse gas emissions and in January 2007 the EU disclosed new climate and energy targets for 2020. Important for reaching these targets are an increase in energy efficiency and energy savings on EU and national levels. Another important policy component is renewable energies. In 2007, targets were announced for 2020, by when 20% of the energy consumed should come from renewable sources.

These targets have to be seen in the context of the current state of renewable energies. In 2005, renewable energies accounted for only 8.5 % of energy consumption in the European Union. Biomass constitutes the largest source of renewable energies in the EU (66%), and wood is the major source for biomass (89%). Thus, wood is currently the major source for all renewable energy generation in the EU.

The paper is based on a study carried out by the University of Hamburg and the Timber Section of United Nations Economic Commission for Europe (UNECE/FAO). More detailed results are reported by Mantau et al. (2008) and Hetsch et al. (2008). The study is seen as a contribution to increase the understanding between the forest based and the energy sector and their policies. The main objective of the study is to draw a better picture of the current (2005) supply and use of wood and, on the other hand, to estimate possible implications of new EU energy targets for the wood use in Europe. Metsäteho, a participant in the study, has reviewed the results in this paper from the viewpoint of Finland and Sweden.

## Methods

The structure of "wood resource balance" developed by Mantau (2005) is used in the study. A wood resource balance compares the entire supply of wood fibres with its use for material and energy purposes in a national economy. It is a consistency check of national wood flows that counter-checks the balance sheet total all sources of woody material against the independently derived balance sheet total of the consumption side (Figure 1). It is important to note, that the figures in wood resource balance include all cascade (multiple) use for raw material.

The method includes also wood fibres import and export at national level. It considers only publicly available information and data from international databases. Important sources of information on the wood sector are:

- The Joint FAO/ UNECE/ ITTO/ Eurostat Forest Sector Questionnaire (JFSQ)
- Joint FAO/ UNECE/ IEA/Eurostat Wood Energy Enquiry (JWEE)
- MCPFE/ UNECE/ FAO enquiry on quantitative indicators of sustainable forest management.
- Energy information comes from European commission (Eurostat, DG TREN), World Energy Outlook 2006 (IEA 2007) and the EurObserver.

• Information on post consumer recovered wood derives from the results of the COST E31 on recovered wood.

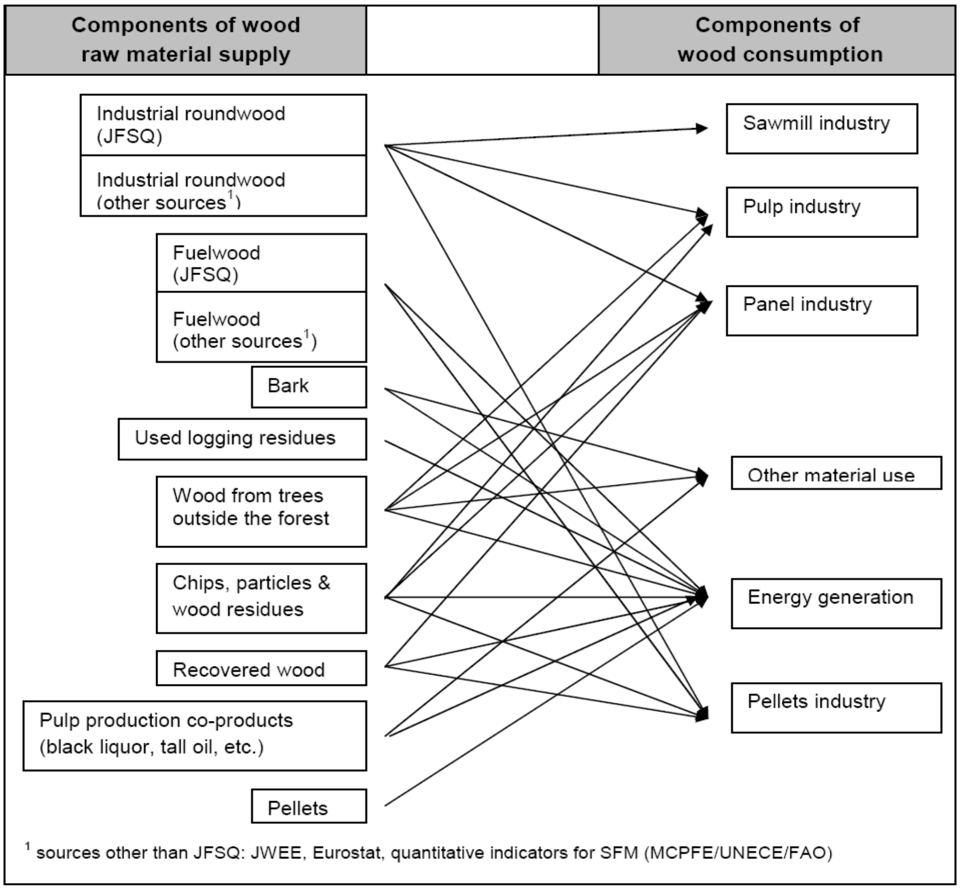


**Figure 1.** Wood flows in the wood resource balance

In order to compare all different commodities, a common unit is needed. Therefore, all figures in the balance are converted into roundwood equivalent (cubic metre of solid volume under bark). On the use side each wood processing technique of the different forest based sector industries requires individual conversion factors to calculate the sector specific solid wood equivalent of the recorded production. The apparent cascade use is counteracted by including certain flows on both sides

In the second part of the study national and EU policy targets for renewable energy are gathered and transparent scenarios are build to "translate" these policy targets into volumes of wood possibly required to meet the targets. Furthermore, the study calculates wood consumption by the wood-based industries for 2010 and 2020, based on the European Forest Sector Outlook Study (UNECE 2005). The wood requirements from EFSOS and the policy targets are then added up, to estimate wood requirements in 2010 and 2020 of both, the energy and wood-based industries.

# Results

## Wood supply 2005

The European wood resource balance covers wood flows in 27 member states of the European Union (EU 27) and two EFTA states - Switzerland and Norway. The total wood volumes extracted from the forests including industrial roundwood, fuelwood, bark and logging residues, add up to 512 Million m³ (EU 27) respectively 531 Million m³ (EU/ EFTA) (Table 1).

Wood from the forest is the most important source of wood raw material, providing 2/3 of the total wood supply. Woody biomass outside the forest, industry co-products, recovered wood or processed wood fuels provide 1/3 of the total supply.

**Table 1.** Wood sources 2005

| | **Wood supply from forest (direct)** | **Wood supply from other sources** | **Total** |
|---|---|---|---|
| | Million m³ | | |
| **EU-27** | 512 | 237 | 749 |
| **EU/EFTA** | 531 | 244 | 775 |

## Wood use 2005

Material use is any process where wood is used to produce goods like sawnwood, pulp and paper, wood-based panels and other products. All these processes have in common that the wood fibres or particles contained in the products and co-products can be reused in downstream processes, recovery or recycling processes. In EU/EFTA the material use of wood accounts for 58% of the total wood use from all sources (Table 2).

**Table 2.** Wood use 2005 (EU/EFTA)

| | **Material use** | | **Energy use** | | **Total use** |
|---|---|---|---|---|---|
| | **million m³** | % | **million m³** | % | **million m³** |

| | | | | | |
|---|---|---|---|---|---|
| **EU-27** | **462** | *58* | **332** | *42* | **794** |
| **EU/EFTA** | **481** | *58* | **341** | *42* | **822** |

The energy use of wood is smaller than the overall material use by all wood based sectors. However, most countries have a much higher proportion of wood use for energy than recorded in international energy statistics. About 42 %, or 341 million m³ (EU/EFTA) of the total wood volumes available are already nowadays used for energy generation.

Among the wood-based industries' sector, the sawmill industry is the biggest wood consumer of solid roundwood for material purposes using 217 million m³ – corresponding to 26% of total consumption. The pulp and paper producing industries are second accounting for 155 million m³ (19% of total consumption) followed by the panel industry (11%) consuming 88 million m³ respectively.

**Balance 2005**

In the national wood resource balances, available wood volumes often do not match volumes of wood use. Summing up the supply and use balanced of all 29 countries, the regional wood resource balance comes to a final difference of 47 million m³ - corresponding to 5% difference (Table 3). The imbalance is probably due to by weak and missing data on both sides of the balance (e.g. data on woody biomass supply from outside the forest, supply of post consumer recovered wood, use of logging residues), different ways of data calculation as well as problems with conversion factors.

**Table 3.** Wood resource balance 2005 (EU/EFTA)

| Sources | [mil. m³] | % | % | [mil.m³] | Uses |
|---|---|---|---|---|---|
| Industrial Roundwood - JFSQ | 381 | 49% | 26% | 217 | Sawmill industry |
| Industrial Roundwood - other | 16 | 2% | 11% | 88 | Panel industry |
| Fuelwood - JFSQ | 79 | 10% | 19% | 155 | Pulp industry |
| Fuelwood - Maximum other | 6 | 1% | 1% | 7 | Pellets, briquetts, etc. |
| Bark | 25 | 3% | 2% | 14 | Other physical utilization |
| Used logging residues | 23 | 3% | 6% | 49 | Power and heat genertion |
| Woody biomass outside forest | 20 | 3% | 8% | 65 | Industrial internal energy use |
| Chips, particles & co-products | 118 | 15% | 11% | 92 | Energy in private households |
| Pulp production co-products | 70 | 9% | 16% | 135 | Undifferentiated energy use |
| Recovered wood | 29 | 4% | | | |
| Processed wood fuel | 7 | 1% | | | |
| **Σ supply total:** | **775** | **▲ 47** | | **822** | **Σ use** |

**Future wood demand**

The European Forest Sector Outlook Study (EFSOS) presents long term trends for supply and demand of forest products (roundwood, sawnwood, panels, pulp, paper, non-wood products) and services and outlook to 2020 (UNECE 2005). According to the baseline scenario of EFSOS, the wood-based industries will consume 483 million m³ in 2010 and increase to 523 million m³ in 2020 (Table 4). It is important to note, that these figures include intentional cascades for raw material, as explained earlier.

**Table 4**. EU/EFTA future wood required to fulfil EFSOS scenario and renewable policy objectives

| | Material use (EFSOS scenario) | Energy targets (RES scenario) | Total use |
|---|---|---|---|
| | million m³ | | |
| 2005* | 466 | 341 | 807 |
| 2010 | 483 | 426 | 909 |
| 2020 | 523 | 696 | 1,219 |
| 2020 /"75% scenario" | 523 | 538 | 1,061 |

*actual figure

The analysis concerning future wood demand for energy is based on national and EU targets for renewable energy, bioenergy and wood energy (if available). These targets have been translated into wood volumes, by applying a number of assumptions (each referring to the situation at country level):

1. For *future final energy consumption*, it was assumed that it would stay at the level of 2005. In cases were countries had official scenario for future energy consumption, it was used.
2. The official policy targets for *the share of renewable energy to* final energy consumption were applied according to the EU or national targets.
3. *The amount of wood needed for energy* (wood energy) was calculated by assuming the same share of wood to renewable energy as in 2005 (55% contribution of wood for EU 27).
4. *The 75% scenario* for 2020 assumes relative decrease of wood by 25% in the overall renewable energy mix (41% contribution of wood for EU 27)

Applying the assumption listed above, the target for renewable energy in final consumption in the EU/EFTA is 150 mtoe in 2010, of which 74 mtoe would originate from wood energy. To produce this amount of energy 426 million cubic meters wood equivalent were needed (Table 4). In 2020 even 696 million cubic meters wood were needed for energy production. The results for each country on EU/EFTA area are presented in figure 2.

Wood energy has the highest share of all renewable sources in 2005 in most countries. Therefore, an increase in renewable energy would affect wood energy the most, if the relative shares of different energies would remain constant. However, in particular this assumption seems unlikely in the long term, since other renewable energies will develop further and faster (on the basis of much lower absolute figures) and become more competitive. Therefore, the study suggests a scenario, where the relative share of wood compared to all other renewable energy sources decreases to 75% of the percent share in 2005 by 2020.

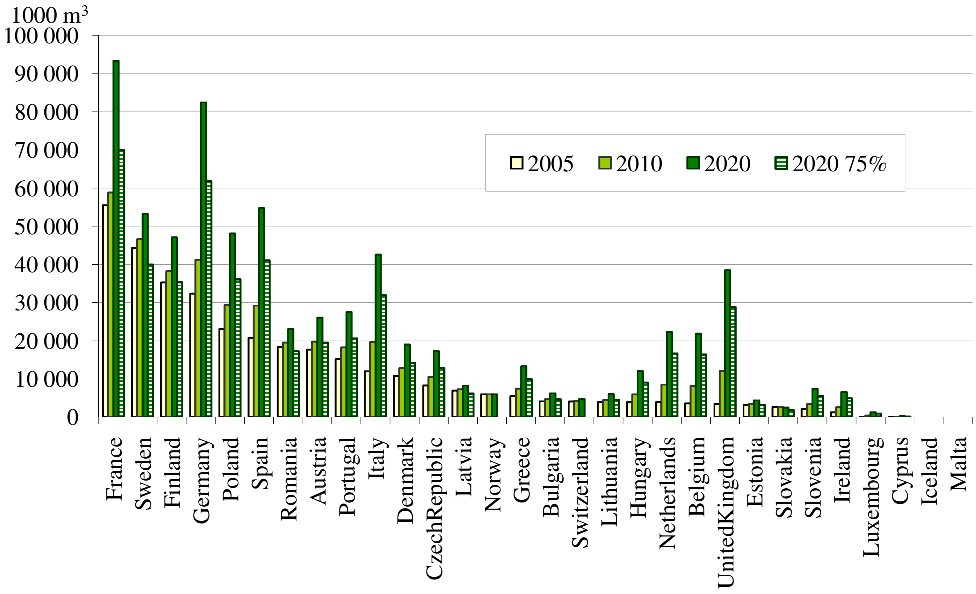


**Figure 2.** Wood required to fulfill energy policy targets in EU/EFTA countries

If the energy objectives were achieved and the wood-based industries would develop as forecasted in EFSOS, a steep increase in wood raw material supply would be required: 102 million m³ wood until 2010, compared to 2005, corresponding to an increase of 13%; and another 310 million m³ (compared to 2010) in 2020 (+34 % compared to 2010). The 75% scenario would require less wood: an increase of 152 million m³ would be needed between 2010 and 2020 (+17%).

**Future wood supply versus wood demand**

The EFSOS baseline scenario proposes that industrial roundwood removals from the forests in EU/EFTA will increase to 536 million m² in 2010 and 569 million m³ in 2020. The total supply comprises wood from forest, from outside the forest as well as all sorts of co-products from the wood-based industries. Future wood supply from fuelwood, trees outside forests and unregistered wood removals were assumed to remain unchanged, as no information is available in EFSOS. The calculated total amount of wood supply will sum up to 783 million m³ in 2010 and 824 million m³ in 2020 (Table 5). The future total wood supply is estimated to increase by 10 million m3 in 2010 and by 44 million m³ in 2020 (both compared to 2005).

Assuming that both, EFSOS and the policy targets, developed as outlined in this study, much more wood would be required than available in the supply scenario (Table 5). The difference would be 126 million m3 in 2010 and 395 million m³ in 2020 (or 237 million m³ in the 75%-scenario).

**Table 5.** Wood supply versus wood required to fulfil EFSOS projections and policy objectives (EU/EFTA)

| Year | Total wood supply * | Wood demand ** | Difference |
|---|---|---|---|
| | million m³ | | |
| 2010 | 783 | 909 | 126 |
| 2020 | 824 | 1,219 | 395 |
| 2020/75% | 824 | 1,061 | 237 |

* direct from the forest and indirect (EFSOS forecast)
** required to fulfil EFSOS projections and policy objectives

However, these numbers have to be interpreted very carefully. The supply data predicts actual roundwood removals from the forest (and not a theoretical potential), based on the EFSOS wood supply model, as well as forecasts for wood processing co-products. The EFSOS supply model is a conservative estimation on wood supply, based on the assumption (from 2000) of only slowly increasing wood demand until 2020. The figures of this study can therefore be seen as minimum potential wood supply, the "real potential" is likely to be higher, and has to be determined given the changing circumstances. But anyhow, the difference between supply and demand gives a rough estimate of additional amount of wood that can be needed into the market in the future.

In the light of existing estimates of Europe's total fuelwood supply potential, this additional raw material requirement presents a substantial challenge. According to recent report, the EU's total annual harvestable forest energy potential stands at 187 million $m^3$ (Asikainen et al. 2008). It should be furthermore noted that a part of this potential is already in use.

**Finland and Sweden at a glance**

Finland and Sweden account for some 30% of total wood consumption within the EU. The two countries also stand alongside Germany and France as Europe's biggest users of wood energy. In 2005, Finland and Sweden used some 80 million cubic metres of wood for energy production. The renewable energy source utilisation targets for Finland and Sweden set by the European Union are 38% (28.5% in 2005) and 49% (40.8% in 2005) respectively of overall final energy consumption by 2020. If wood's share of the total renewable energy sources is kept at its current levels, this constitutes an increase in energy wood use of 12.4 million $m^3$ for Finland and 5.6 million $m^3$ for Sweden (Figure 2). These targets will require Finland to raise wood energy use more sharply than its neighbour Sweden, where other forms of renewable energy, water power in particular, play a bigger role.

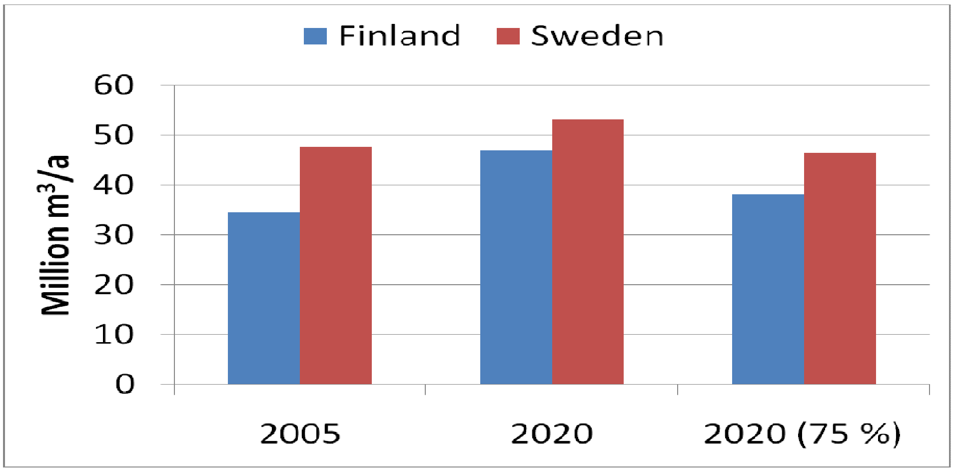


**Figure 2.** Utilisation of wood energy in Finland and Sweden in 2005 and its development according to two different study scenarios

In Finland, around 75% of all wood energy is derived from co-products of the forest industry such as black liquor, bark and sawdust. Opportunities to increase wood energy utilisation are therefore highly dependent on the overall level of wood consumption. Finland's latest National Forest Programme sets a goal of increasing the annual roundwood cuttings by 10–15 million $m^3$ which, due to the country's forest reserves, would appear to be a viable target with regards sustainable wood production (Nuutinen et al. 2007). A key incentive for increasing domestic removals is reduced dependency on imported timber. Russian roundwood imports to Finland have in recent years reached about 15 million $m^3$ per year, totalling about one fifth of the country's total wood consumption. However, Russia has decided to raise timber export tariffs to EUR 50/m$^3$, effectively putting an end to imports of Russian wood to Finland. Even if domestic timber were to be successfully mobilised to cover these import volumes, the increase in domestic fellings would not, however, increase the amount of wood energy obtained from industrial co-products. On the other hand, increased domestic fellings would certainly boost the harvesting possibilities of logging residues and stumpwood.

The techno-economical harvesting potential of logging residues, stumpwood and non-commercial small-diameter wood has been estimated by several studies in Finland (e.g. Hakkila 2004, Puupolttoaineiden ... 2007). According to them the harvestable potential of forest chips is 10 – 15 million m$^3$ per year. However, this represents the ceiling level, the real usefulness of which is dependent for example on the location of the energy plants, on the amount of the domestic roundwood removal and the willingness of forest owners to sell logging residues and stumps. Finnish forest chip production currently stands at around 3.5 million m$^3$ per year.

In summary, Finland's renewable energy targets are very challenging if they are to be fulfilled predominantly by wood energy. The outlook for growth in roundwood consumption and co-products production by the Finnish forest industry is minimal to negative. In practice, therefore, the entire wood energy increase must be achieved through forest chips and small-scale household use, meaning that virtually the entire harvestable forest chip potential of Finland would have to be mobilised and cost-effectively supplied to its users. This is not realistic. The development of other forms of renewable energy does, therefore, appear to be of vital importance.

## Conclusions

The wood resource balance for 2005, at the national and EU/EFTA levels shows the broad pattern of wood supply and use in demand. Unevenly distributed data weaknesses on both sides of the wood resource balance confirm clearly that further empirical research is needed at national level. Nevertheless, the regional wood resource balanced allows some first conclusions:

Wood energy is the most important regional renewable energy source at present. Where available, results from empiric studies on wood energy at country level (France/Germany/Norway/Austria) confirm that direct energy use of wood is much higher than previously assumed. The supply for unrecorded use of energy wood is mostly not recorded either. Therefore, these removals have to be taken into account when estimating the available potential wood supply.

Traditional analysis of wood supply and demand, centred on wood removals from forests and wood input to industries seems to be inadequate, since not all sources and uses of wood is considered. Therefore, an up-dated, more complex approach, based on comprehensive wood resource balances, is necessary. Many of the elements for such a wood resource balance are already available, even at the international level, but several other elements need original research and data gathering, notably the following:

- Unrecorded sources of wood supply, in particular trees outside the forest, logging residues, and post consumer recovered wood.
- Unrecorded use of wood, in particular for energy in private households and small CHP plants.
- Input/output conversion factors for wood using industries

Projecting the wood resource balance approach forward to 2010 and 2020 shows that the foreseeable demand for wood is considerably higher than the supply forecast by EFSOS. Although the size of the increase in wood demand is open to discussion, this development is likely to have major impacts on the forest sector. As a matter of urgency, the sector should focus on reviewing and confirming the outlook for wood demand for all uses.

There is an equally urgent need to analyse in quantitative terms future potential wood and fibre supply, focussing not only on wood supply from the forest (stem wood and other woody biomass), but also on other sources:

- Woody biomass from outside the forest (arboricultural arisings, urban trees etc)
- Co-products from the forest-based industry
- Post-consumer recovered wood and paper

When assessing potential wood supply, it is important to take local realities into account influencing the availability of these potentials, such as costs, ownership patterns, quality requirements, infrastructure etc.

Another option to increase wood supply would be to increase imports of wood from outside Europe. In this context the sustainability issues of potential supplying regions must also be taken into account.

At present, the forest outlook for Europe is for much stronger demand than forecasted even a few years ago, as energy needs, influenced by policy, are added to the projected raw material demand. There is potential to increase wood supply, which is at present still below its sustainable maximum. However, very considerable uncertainty surrounds both the strength of the increased demand and the limits to sustainable wood supply. This uncertainty is harmful to the sector and to rational policy formulation

In order to adequately assess future wood demand and supply, a comprehensive outlook study for the forest sector is needed, taking developments in the energy sector into account, as well as all elements of wood supply.

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# Assessing effects of participatory forest management on forest conservation; A case of village managed miombo woodland forest in Iringa, Tanzania

Jens Friis Lund, Henrik Meilby, Thorsten Treue

Participatory forest management (PFM) in Tanzania has the triple objective of (i) conserving forest resources, (ii) improving rural economic development and (iii) promoting good governance, including democratic decision-making, at local level. This paper is predominantly concerned with assessing the effects of PFM on forest conservation in two village forest reserves, Mfyome and Kiwele in Iringa district, Tanzania. The approach has been to estimate whether the harvest of woody biomass is within the reproductive capacity of the forest. An inventory of the growing stock through temporary sample plots and literature-based estimates of the annual increment is used to estimate forest growth and village records, household interviews as well as an inventory of charcoal production sites and interviews with charcoal producers are used to estimate the annual outtake. Results suggest that local management of the forests has, in fact, resulted in harvest levels that are within the estimated growth. Whether this includes conserving a *desirable* species composition in terms of preferred timber charcoal as well as firewood species is, however, uncertain. Yet, investigations of management rules and their enforcement, which include protection of timber species from being cut for charcoal and firewood production, suggest that village-level managers are to a large extent capable of devising and enforcing silviculturally sound management rules. Accordingly, the study supports the hypothesis that securing local ownership to local forest resources, products and revenues will promote conservation of forests that used to be, de facto, open access resources irrespective of their official status. However, longitudinal monitoring is needed to establish more firm conclusions about the effects of PFM on forest conservation.

Keywords: Participatory forest management, forest conservation, Tanzania

# Estimating forest product values in Central Himalaya - methodological experiences

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## Abstract

Forests are crucial to the livelihoods of millions of poor people in developing countries. Yet quantitative approaches to estimate the economic value of forest products and other environmental resources at household-level across different sites have only recently been developed and experiences on using such methods are only presently emerging. This paper presents methodological experiences from using a structured household survey approach to estimate household forest dependency in two high altitude areas in Central Nepal. Area and village level background and contextual information was collected using qualitative techniques; this was followed by a structured household ($n$ = 180) survey conducted over a full year from December 2005 to December 2006. Households were randomly selected and inter alia subjected to quarterly income surveys. The emphasis in this paper is on investigating whether own-reported value data is valid and reliable. It is concluded that it is reasonable to use households own-reported values as these estimates produced aggregated unit values with acceptable properties.

**Keywords**: Economic valuation, valuing environmental resource use, Nepal

## 1. Introduction

Forests are crucial to the livelihoods of millions of poor people in developing countries. But just how important are they in preventing and reducing poverty? Which types of forests and products count most for the poor? Are forests mainly useful as gap-fillers and safety nets preventing extreme hardship or can they help lift people out of poverty? How do different forest management regimes and policies affect the benefits poor people derive from forests? Answers to such questions are essential to design effective forest policies and projects, and to incorporate forest issues in poverty reduction strategies. Yet we have surprisingly little empirically based knowledge to answer such questions adequately.

Research on the role and potential of forests in preventing and reducing poverty is limited and can be considered an emerging field of inquiry. Existing literature has been critically examined with the aim of understanding forest-poverty linkages and the potential of forests in poverty alleviation (Arnold and Bird, 1999; Arnold, 2001; Wunder, 2001; Angelsen and Wunder, 2003; Scherr et al., 2004; Sunderlin and Ba, 2005), and a recent World Bank paper used a meta-analysis to assess rural dependence on forest income (Vedeld et al., 2004). Available studies clearly show that comparisons of forest product valuation studies are generally not possible because of varying methods (e.g. Campbell et al., 2002; Cavendish, 2002; Godoy and Bawa, 1993; Gram, 2001; Narian et al., 2005; Vedeld et al., 2004; Wollenberg and Nawir, 1998). An important consequence of this is that forest income remains excluded from official data collection and thus is largely invisible to policy makers. There is therefore a need to develop best-practice methods for assessing the role of forests and other environmental resources in rural livelihoods, and then create a critical mass of good and comparable data. Methods should be developed for use at household level, cover all income sources comprehensively, be quantitative and be described in detail (Cavendish, 2002). Such methods have recently been developed by the Poverty and Environment Network (PEN introduction 2008, PEN prototype questionnaire 2007, PEN technical guidelines 2007) and empirical data collection is taking place across a variety of sites. This paper reports methodological findings, using the PEN prototype questionnaire and approach, on forest product valuation in a high altitude remote site in the Central Nepal Himalaya. The emphasis is on (i) investigating whether own-reported volume and value data is valid and reliable, and (ii) how to value products that are neither traded or bartered and where there are no useful substitutes on which to base valuation.

### 1.1 Case study area

Field work was undertaken in two Village Development Committees (VDCs – the lowest administrative unit) in the lower part of Mustang District (around 28°34'-28°41' N and 83°33'-83°44' E) in the Western Region of Nepal. Each VDC is made up of three villages. Altitudes are above 2000 masl with a temperate to sub-alpine climate; annual average precipitation is approx. 1500 mm.

Land use is characterised by upper and higher elevation subsistence production type systems (Metz, 1989, 1990; Olsen, 1996): large areas of rainfed fields whose fertility is mainly maintained through use of composted manure. Livestock dominated by cattle, sheep and goats.

Transhumance is common and there are large grassland and forest areas, including around 3000 ha of essentially closed canopy forests consisting of conifers (*Pinus*, *Cupressus*, *Abies*, *Tsuga*, *Taxus*) and mixed broadleaves (*Ilex, Rhododendron, Neolitsea, Acer, Betula, Populus*). Community-based grassland and forest management is common. The forest area per capita is about 1.7 ha as is the per capita area of grassland under community-based management. The most common sources of off-farm income are agricultural labour, portering, long distance trade, and from involvement in tourism (the study area is located in the Annapurna Conservation Area, a popular trekking destination).

The study area is characterized by a considerable level of forest dependency, e.g. through use of forest fodder to feed livestock and forest litter as input in compost production, and widespread poverty, e.g. the area has one of the lowest Human Development Indexes in the world (0.136 according to DDC 2002).

## 2. Methods

This section briefly explains how forest income data was collected, checked, cleaned and valued. Essentially, data collection and handling followed the procedures specified in the PEN prototype questionnaire (2007) and the PEN technical guidelines (2007), i.e. first qualitative rural appraisal at village level subsequently used to adopt the prototype questionnaire to the local context, then testing of structured questionnaires, random selection of households, and application of questionnaires. Appraisal field work started in October 2005 and the last quarterly survey was conducted in December 2006.

The prototype questionnaire was translated into Nepali (PEN Nepali, 2008) by a team of faculties from the Institute of Forestry (IOF) at Tribhuvan University. All translated structured questionnaires were then tested in a village outside the sampling frame; based on this testing the final translations were worded.

Before field work commenced enumerators and supervisors were identified, selected and trained. Six high school graduate local enumerators (two female and four male) were thoroughly trained in a one-week programme and then used for the entire period of the survey. Trained IOF faculty supervised the local enumerators and checked the quality of the data and data collection; they participated in interviews and checked completed questionnaires. After coding in the field these were again checked and verified for consistency before entering into a unique yet simple MS Access database. Errors and inconsistencies were resolved by returning to households for clarification.

### 2.1 Rapid appraisal

In each village in each VDC contextual information, e.g. on village history and resource use patterns, was solicited through semi-structured village meetings, focus group discussions and key informant interviews. This included participatory resource mapping, drawing up an annual calendar of key activities, and making detailed lists of forest products used for both subsistence and commercial purposes.

### 2.2 Household-level structured surveys

An overview of the population and sample size and distribution is provided in Table 1. To allow detailed intra- and inter village level analyses a large number of households (*n* = 194) were sampled – 56% and 59% in the two VDCs respectively. Sampled households were randomly selected using an up-dated census list from each VDC office and a computer generated random table. At survey end, 14 households were excluded from the data set due to incomplete information or because validity was estimated to be low – at end of field work enumerators estimated household-level truthfulness on a scale of 1 to 3, with 1 being not valid and 3 being very valid. The average score was 2.43 with a vast majority of households estimated to provide very valid or valid responses. This good result is primarily due to the skilful local enumerators, their hard work and good rapport with the respondents.

**Table 1** Population and sample size and distribution, 2006

| Description | Kunjo VDC | Lete VDC | Total |
|---|---|---|---|
| **Total population** | 826 | 911 | 1737 |
| **Total households** | 163 | 174 | 337 |
| **Average household size** | 5.1 | 5.2 | 5.2 |
| **Sampled households** | 92 | 102 | 194 |

Two types of structured surveys were carried out: annual household surveys (at survey start and survey end) and four quarterly household surveys. The first annual household survey provided basic household information (demographics, land holding, assets, access to forest, relation to forest institutions, markets for forest products) while the second annual survey focus on changes (in assets, household level crises and unexpected expenditures, payments for forest services, welfare perceptions). The four quarterly surveys were basically designed for collecting high quality income data, including detailed questions on forest products. Off-farm and non-farm wage income contributed by each household member was recorded. Data was collected to allow calculation of net income from product processing and businesses (gross income minus costs of production). Indeed, data was collected to allow for detailed calculation of net income for all types of activities, including costs of agricultural inputs such as seeds, fertilizer and hired labour and basic livestock data such as each species' mortality and natality. Non-farm income included a range of activities such as interest earned, remittances (both cash and in-kind payment from family, friends and the state) and inheritance.

All selected households were informed of the purpose of the research in advance through an official letter. Whenever possible two adult household members, always including the household head, were interviewed. On average a household-level interview lasted 45 minutes.

Local volume units were standardized to SI units through repeat weighing of all units for all major products. Valuation was, whenever possible, done by reporting farm-gate prices; if not available valuation was done using barter values, substitute prices, distant market prices or value of time (labour – see also PEN technical guidelines 2007). This time consuming work was possible as researchers were in the study area throughout the year.

## 3. Results

In the research project underlying the present paper, estimating the true sustainability of household-level income is important. Therefore, here, some attention is paid to converting local volume units to SI units though this information is not strictly required to just estimate household income using the above approach. This is then followed by investigating basic distributional statistics for unit values in order to check whether own-reported values are useful. For products where no own-reported values can be obtained, the assumptions and techniques used to estimated values are presented; particular attention is paid to the key products browse and graze.

### 3.1 Conversion of local volume units to SI units

A total of 115 forest, non-forest environmental, agricultural and livestock products, reported in many different local units, are used for both subsistence and commercial purposes. Some products are reported in many different units, e.g. fuelwood may be reported in large or small rope-tied backloads (bhari) or in large or small bamboo baskets (doko). The results of the weight and volume measurements of products of major importance to households are presented in Table 2. In general, the median and modal values are close to the mean, and standard deviation is much less than the mean. The traditional local volume measures mana and pathi are related: eight mana to one pathi. This relationship is not found for all products; the least accurate figures are for garlic (5.6:1) and barley (6.3:1). Deviations are due to the variation created by (i) differences in moisture contents (products can be fresh, semi-dry or dry), (ii) use of available local volume vessels instead of two high quality standard vessels, and (iii) intra-species product variation, e.g. fine grain weighs more than coarse grain per unit. This indicates that, for some products, the number of observations should be increased.

**Table 2** Conversion of local units to SI units for forest, non-forest environmental and agricultural products in Lower Mustang District, 2006 (only includes products where $n > 5$)

| Products | Local unit | SI unit | N | Min | Max | Median | Mean | s.d. |
|---|---|---|---|---|---|---|---|---|
| **Maize** | pathi | gram | 12 | 3350 | 4500 | 3775 | 3775 | 313.0 |
| | mana | gram | 12 | 390 | 450 | 423 | 420 | 18.6 |
| **Barley** | pathi | gram | 10 | 2450 | 2775 | 2513 | 2563 | 97.4 |
| | mana | gram | 10 | 350 | 455 | 418 | 405 | 36.6 |
| **Naked barley** | pathi | gram | 12 | 3000 | 3600 | 3295 | 3274 | 184.9 |
| | mana | gram | 7 | 400 | 500 | 470 | 451 | 34.9 |
| **Green chilly** | mana | gram | 6 | 310 | 450 | 410 | 383 | 50.5 |
| **Beans** | pathi | gram | 8 | 3200 | 3800 | 3375 | 3450 | 218.8 |
| | mana | gram | 10 | 350 | 450 | 395 | 406 | 33.1 |
| **Buckwheat** | pathi | gram | 12 | 2300 | 2900 | 2780 | 2707 | 192.7 |
| | mana | gram | 10 | 350 | 450 | 388 | 387 | 29.2 |
| **Potato** | pathi | gram | 10 | 2700 | 3100 | 3000 | 2955 | 132.2 |
| | mana | gram | 11 | 350 | 525 | 400 | 405 | 48.4 |
| **Garlic dry** | pathi | gram | 10 | 1800 | 2400 | 2175 | 2130 | 184.4 |
| | mana | gram | 9 | 350 | 410 | 380 | 378 | 23.7 |
| **Mushroom (dry tawe)** | pathi | gram | 8 | 250 | 350 | 295 | 290 | 30.8 |
| | mana | gram | 10 | 35 | 50 | 43 | 42 | 5.8 |
| ***Zanthoxylum armatum* fruits** | mana | gram | 10 | 120 | 210 | 175 | 166 | 32.3 |
| **Fuelwood** | L-bhari | kg | 10 | 40 | 49 | 43 | 44 | 3.4 |
| | S-bhari | kg | 7 | 30 | 39 | 38 | 36 | 3.1 |
| | L-doko | kg | 8 | 44 | 55 | 48 | 48 | 4.0 |
| | S-doko | kg | 16 | 28 | 42 | 32 | 33 | 3.9 |
| **Charcoal** | doko | kg | 9 | 21 | 28 | 26 | 25 | 2.2 |
| | bora[1] | kg | 8 | 11 | 15 | 14 | 14 | 1.3 |
| **Fodder grass** | mutha[1] | kg | 17 | 0.8 | 1.1 | 1.0 | 0.9 | 0.1 |

| Products | Local unit | SI unit | N | Min | Max | Median | Mean | s.d. |
|---|---|---|---|---|---|---|---|---|
| **(high quality - sanchi dry)** | | | | | | | | |
| **Fodder grass** | | kg | | 3.9 | 5.2 | 4.3 | 4.5 | 0.5 |
| **(sanchi fresh)** | mutha | | 7 | | | | | |
| **Bamboo (nigalo)** | bhari | kg | 15 | 20 | 31 | 24 | 24 | 3.3 |
| **Compost manure** | doko | kg | 15 | 16 | 36 | 28 | 26 | 7.0 |
| **Bamboo shoot** | | kg | | 2.5 | 4 | 2.9 | 3.2 | 0.6 |
| **(tusa)** | mutha | | 7 | | | | | |
| **Fodder grass (ordinary)** | bhari | kg | 22 | 22 | 47 | 28 | 30 | 7.5 |
| | doko | kg | 21 | 18 | 40 | 33 | 30 | 6.9 |
| **Pole (large, bolo)** | piece | $m^3$ | 47 | 0.007 | 0.227 | 0.105 | 0.104 | 0.035 |
| **Pole (small,** | | $m^3$ | | 0.022 | 0.088 | 0.039 | 0.044 | 0.013 |
| **khamba)** | piece | | 60 | | | | | |
| **Stick (sata, taiyu)** | piece | $m^3$ | 28 | 0.003 | 0.009 | 0.007 | 0.006 | 0.003 |
| **Beam (dalin)** | piece | $m^3$ | 62 | 0.071 | 0.189 | 0.142 | 0.131 | 0.027 |
| **Beam (satari)** | piece | $m^3$ | 58 | 0.042 | 0.142 | 0.071 | 0.072 | 0.018 |
| **Planks (falek)** | piece | $m^3$ | 61 | 0.005 | 0.021 | 0.012 | 0.013 | 0.003 |

[1] Bora is a large sack and mutha is a small bundle

## 3.2 Checking own-reported values

In his ground-breaking study of environmental resource use in Zimbabwe, Cavendish (2002) concluded that own-reported values are generally a good measure of the value of environmental resources. Whether this also holds true in the present high altitude Central Himalayan study area is investigated in this section – basic distributional statistics for unit values of the main forest, non-forest environmental, agricultural and livestock products are presented in Table 3. The column "Valuation method" specifies the dominant method used to value each product: local market means that the basis is farm-gate price; barter means that value is derived from trade with a market commodity; substitute that valuation is through a close substitute with a local market price; distant market that valuation uses the price at a distant market deducted for transport costs; and time means that valuation is done based on labour time multiplied by the relevant local daily wage rate (varies with season and gender). The valuation methods are listed in order of preference.

In general, all agricultural products could be valued using farm-gate prices (77%) or barter values (23%); for livestock products farm-gate prices (90%) were generally available – the main exception being manure (see section 3.3). This pattern is different for the large group of forest and non-forest environmental products: for 31% farm-gate prices are available, while barter is used for 10%, substitute pricing for 23%, distant market prices for 13% (nearly all medicinal plant products), and labour time for 23%. Product-level choice of valuation technique, when farm-gate and barter pricing were not possible, was generally determined by use, harvesting and trading patterns: using close substitute whenever possible, otherwise using distant (road head) market prices for traded goods and estimating the opportunity cost of labour for products collected during discrete harvesting trips. See also section 3.3 for how valuation of difficult products were undertaken.

For most products the mean, median and modal units are very close in value showing little skewness, and in general the standard deviation is lower than the mean and in many cases lower than half the mean. This indicates that own value estimates reflect resource values (rather than being just arbitrary answers provided by respondents who feel obliged to participate in the research). Products deviating from this pattern (notably wooden furniture, poles, cattle) are arguably quite heterogenous (e.g. size, quality) and we would expect high variation in unit values. For some products, the number of observations are too low to ensure good estimates, e.g. the unit value of a doko of fuelwood ($n$ = 8) would vary according to the species composition and the wood moisture content. Such intra-product quality variation was not recorded and is a cause of dispersion in the unit values. Thus, to arrive at estimates with acceptable properties, it is important to disaggregate products as much as possible. Product differences are reflected in the large differences in minimum and maximum values of many products – a span also influenced by spatial and temporal variability in values. The latter is seen in the seasonal value variation for selected products, with a high number of observations, in Table 4.

In the last column in Table 3, the product unit value (typically Nr/kg) is provided; this should be similar regardless of local unit and valuation technique used. This is generally the case though there are exceptions, e.g. for garlic, ghee and wild vegetables. It should be noted that value/local unit is more accurate than the value/SI unit as the latter is calculated using a weight conversion factor; as seen in Table 2 this may require many (more) observations to establish estimates with good properties. We would also expect the unit price of processed products to be higher than for raw materials; this is consequently the case in Table 3, e.g. when comparing raw and processed bamboo (chitro, doko, kaap), fuelwood and charcoal, timber and wooden furniture, poles and ploughs, milk and butter/cheese/ghee.

**Table 3** Own-reported unit values (Nr) of forest, non-forest environmental, agricultural and livestock goods in Lower Mustang District, 2006 (100 products where $n \geq 5$)

| Products | Local unit | n | Min | Max | Median | Mean | s.d. | Valuation method | Nr/kg[1] |
|---|---|---|---|---|---|---|---|---|---|
| **I. Forest and non-forest env. products** | | | | | | | | | |
| **Bamboo product (chitro)** | piece | 48 | 100 | 350 | 200 | 199.4 | 55.1 | local market | 33 |
| **Bamboo product (doko)** | piece | 111 | 50 | 150 | 100 | 93.6 | 15.5 | local market | 31 |
| **Bamboo product (kaap)** | piece | 13 | 10 | 30 | 10 | 12.7 | 6.0 | local market | 28 |
| **Charcoal** | doko | 21 | 100 | 300 | 170 | 164.3 | 63.5 | local market | 7 |
| | bora | 148 | 50 | 200 | 100 | 115.4 | 28.4 | local market | 9 |
| **Fodder grass (dry sanchi)** | mutha | 235 | 5 | 40 | 8 | 12.0 | 8.1 | local market | 3 |
| **Juice (seabuckthorn)** | litre | 22 | 100 | 400 | 100 | 123.2 | 65.2 | local market | 123(/l) |
| **MAP (yarsagumba)** | piece | 11 | 30 | 50 | 30 | 35.5 | 6.9 | local market | 142000 |
| **Mushroom (guchi)** | kg | 16 | 500 | 4000 | 4000 | 2687 | 1750 | local market | 2687 |
| **Mushroom (tawe dry)** | pathi | 59 | 200 | 350 | 300 | 298.3 | 20.7 | local market | 1029 |
| | mana | 11 | 10 | 130 | 40 | 46.8 | 31.6 | local market | 1170 |
| **Lumber** | $m^3$ | 159 | 3531 | 17657 | 6357 | 6519 | 1244 | local market | 6519(/$m^3$) |
| **Wooden furniture** | piece | 27 | 20 | 4500 | 1000 | 1258 | 1325 | local market | 11438(/$m^3$) |
| | set | 20 | 500 | 5000 | 1625 | 1940 | 1145 | local market | 9700(/$m^3$) |
| **Wooden tool (agri.)** | piece | 97 | 10 | 170 | 15 | 23.9 | 29.4 | local market | 7980(/$m^3$) |
| **Wooden tool (plough)** | piece | 44 | 200 | 1000 | 500 | 511.4 | 229.2 | local market | 10227(/$m^3$) |
| **Walnut** | kg | 21 | 20 | 40 | 20 | 27.1 | 9.6 | local market | 27 |
| ***Z. armatum* fruit** | mana | 20 | 40 | 70 | 60 | 59.0 | 8.5 | local market | 358 |
| **Bamboo shoot** | kg | 205 | 10 | 60 | 40 | 36.9 | 15.0 | barter value | 37 |
| | mutha | 130 | 10 | 60 | 30 | 34.5 | 13.2 | barter value | 35 |
| **Incense** | bhari | 103 | 90 | 350 | 300 | 259.4 | 69.3 | barter | 12 |

| Products | Local unit | n | Min | Max | Median | Mean | s.d. | Valuation method | Nr/kg[1] |
|---|---|---|---|---|---|---|---|---|---|
| **(diyalo)** | | | | | | | | value | |
| | doko | 165 | 50 | 400 | 100 | 159.6 | 89.6 | barter value | 8 |
| **Ornamental plants** | mutha | 8 | 5 | 30 | 10 | 10.6 | 8.2 | barter value | 11 |
| | piece | 91 | 2 | 30 | 5 | 7.6 | 4.8 | barter value | 23 |
| **Tree bark (incense)** | kg | 7 | 5 | 30 | 20 | 19.3 | 9.3 | barter value | 19 |
| | mutha | 11 | 5 | 20 | 10 | 14.1 | 5.8 | barter value | 14 |
| **Tree leaves** | mutha | 50 | 5 | 50 | 20 | 24.1 | 10.8 | barter value | 24 |
| | piece | 8 | 2 | 10 | 5 | 5.9 | 3.2 | barter value | 18 |
| **Bamboo (broom grass)** | mutha | 55 | 10 | 100 | 40 | 46.2 | 24.4 | substitutes | 5 |
| **Fish** | kg | 6 | 100 | 300 | 220 | 215.0 | 66.3 | substitutes | 215 |
| **Amphibia (medicinal)** | kg | 5 | 60 | 200 | 100 | 112.0 | 52.2 | substitutes | 112 |
| | piece | 24 | 5 | 70 | 50 | 46.5 | 18.5 | substitutes | 122 |
| **Snails (medicinal)** | piece | 7 | 5 | 10 | 5 | 7.1 | 2.7 | substitutes | 143 |
| **Mushroom (tawe fresh)** | kg | 315 | 20 | 300 | 100 | 102.6 | 55.3 | substitutes | 103 |
| **Wild fruit (guyalo)** | kg | 62 | 20 | 50 | 20 | 23.0 | 7.1 | substitutes | 23 |
| **Wild fruit (kopen)** | kg | 48 | 10 | 50 | 20 | 23.5 | 7.3 | substitutes | 24 |
| **Wild fruit (ainselu)** | kg | 5 | 30 | 50 | 30 | 36.0 | 8.9 | substitutes | 36 |
| **Wild veg. (dude-lasune)** | kg | 424 | 5 | 60 | 20 | 23.3 | 7.9 | substitutes | 23 |
| | mutha | 142 | 5 | 80 | 30 | 26.0 | 12.1 | substitutes | 26 |
| | doko | 15 | 100 | 400 | 200 | 183.3 | 69.9 | substitutes | 9 |
| **Wild veg. (dhogayo)** | kg | 32 | 10 | 50 | 20 | 21.4 | 8.2 | substitutes | 21 |
| | bhari | 15 | 200 | 500 | 300 | 313.3 | 83.4 | substitutes | 16 |
| **Wild veg. (green)** | kg | 25 | 10 | 40 | 20 | 23.2 | 7.8 | substitutes | 23 |
| | mutha | 60 | 5 | 50 | 20 | 21 | 11.8 | substitutes | 21 |
| **MAP (chiraito)** | mutha | 8 | 5 | 50 | 10 | 14.4 | 14.5 | distant market | 37 |

| Products | Local unit | n | Min | Max | Median | Mean | s.d. | Valuation method | Nr/kg[1] |
|---|---|---|---|---|---|---|---|---|---|
| **MAP (kutki)** | piece | 11 | 2 | 40 | 10 | 14.7 | 10.3 | distant market | 173 |
| **MAP (nirmasi)** | piece | 6 | 10 | 35 | 20 | 20.0 | 9.5 | distant market | 235 |
| **MAP (satuwa)** | piece | 8 | 5 | 30 | 10 | 11.3 | 8.3 | distant market | 132 |
| **MAP (panchaunle)** | piece | 7 | 10 | 20 | 10 | 12.1 | 3.9 | distant market | 143 |
| **Wooden stick** | piece | 195 | 5 | 40 | 10 | 9.1 | 5.3 | distant market | 3020 |
| **Bamboo** | bhari | 283 | 100 | 430 | 300 | 273.8 | 82.4 | value of time | 11 |
| | piece | 247 | 1 | 20 | 5 | 4.6 | 2.8 | value of time | 10 |
| **Clay (sagarmato)** | doko | 55 | 25 | 200 | 50 | 83.1 | 58.3 | value of time | 3 |
| **Fodder grass (ordinary)** | bhari | 112 | 20 | 130 | 50 | 55.7 | 33.9 | value of time | 2 |
| **Fuelwood (trunk)** | bhari | 357 | 20 | 250 | 80 | 84.1 | 34.7 | value of time | 2 |
| | doko | 8 | 20 | 200 | 45 | 63.8 | 57.3 | value of time | 2 |
| **Fuelwood (branch-twig)** | bhari | 227 | 20 | 300 | 60 | 68.3 | 39.2 | value of time | 2 |
| | mutha | 18 | 10 | 30 | 20 | 22.2 | 6.5 | value of time | 3 |
| **Decayed litter** | bhari | 28 | 20 | 80 | 30 | 34.5 | 14.4 | value of time | 1 |
| | doko | 5 | 25 | 50 | 50 | 40.0 | 13.7 | value of time | 1 |
| **Poles** | piece | 121 | 10 | 800 | 50 | 110.2 | 132.6 | value of time | 2204(/$m^3$) |
| **Thatch grass** | bhari | 11 | 100 | 200 | 150 | 153.6 | 36.7 | value of time | 5 |
| **Tree bark** | bhari | 8 | 30 | 70 | 35 | 38.1 | 13.1 | value of time | 1 |
| | doko | 5 | 20 | 50 | 30 | 34.0 | 15.2 | value of time | 1 |
| **Dry pine leaf litter (sanpat)** | bhari | 100 | 50 | 200 | 100 | 98.3 | 19.13 | value of time | 2 |
| **Mixed leaf litter** | bhari | 137 | 40 | 300 | 60 | 66.75 | 28.17 | value of time | 2 |
| **II. Agricultural products** | | | | | | | | | |
| **Apple** | kg | 10 | 15 | 30 | 20 | 19.0 | 4.6 | local market | 19 |

| Products | Local unit | n | Min | Max | Median | Mean | s.d. | Valuation method | Nr/kg[1] |
|---|---|---|---|---|---|---|---|---|---|
| **Plum** | kg | 5 | 10 | 20 | 20 | 16.0 | 5.5 | local market | 16 |
| **Peach** | kg | 21 | 10 | 30 | 20 | 17.1 | 5.8 | local market | 17 |
| **Barley** | muri | 108 | 800 | 2400 | 1200 | 1151.9 | 254.9 | local market | 22 |
| | pathi | 30 | 40 | 80 | 70 | 66.0 | 7.7 | local market | 25 |
| **Bean** | muri | 71 | 1600 | 4000 | 3000 | 3085.9 | 260.4 | local market | 45 |
| | pathi | 129 | 70 | 200 | 160 | 161.3 | 18.2 | local market | 47 |
| **Buckwheat** | muri | 151 | 1000 | 3200 | 1400 | 1425.8 | 298.1 | local market | 26 |
| | pathi | 47 | 50 | 100 | 70 | 74.1 | 12.2 | local market | 27 |
| **Cabbage** | kg | 436 | 10 | 35 | 20 | 19.7 | 4.4 | local market | 20 |
| **Carrot** | kg | 107 | 10 | 60 | 25 | 25.5 | 9.7 | local market | 25 |
| **Cauliflower** | kg | 188 | 10 | 60 | 30 | 28.2 | 8.6 | local market | 28 |
| **Chilli** | kg | 23 | 20 | 80 | 43 | 44.7 | 17.9 | local market | 45 |
| **Garlic** | kg | 81 | 10 | 100 | 20 | 35.1 | 25.2 | local market | 35 |
| | pathi | 80 | 50 | 300 | 150 | 147.3 | 40.8 | local market | 49 |
| **Green leafy veg** | kg | 322 | 10 | 80 | 15 | 19.9 | 13.4 | local market | 20 |
| | mutha | 298 | 5 | 60 | 15 | 16.2 | 5.3 | local market | 16 |
| **Maize** | muri | 304 | 1000 | 1800 | 1200 | 1227 | 112.0 | local market | 16 |
| | pathi | 17 | 40 | 70 | 60 | 60.6 | 8.1 | local market | 16 |
| **Onion** | kg | 31 | 10 | 80 | 40 | 34.7 | 17.4 | local market | 35 |
| **Potato** | pathi | 196 | 40 | 120 | 60 | 57.5 | 11.8 | local market | 19 |
| | muri | 241 | 600 | 1600 | 1000 | 998.6 | 241.3 | local market | 17 |
| **Soyabean** | muri | 10 | 2000 | 4000 | 2750 | 2840 | 751.6 | local market | 41 |
| | pathi | 48 | 100 | 300 | 155 | 162.6 | 49.9 | local market | 46 |

| Products | Local unit | n | Min | Max | Median | Mean | s.d. | Valuation method | Nr/kg[1] |
|---|---|---|---|---|---|---|---|---|---|
| **Tomato** | kg | 29 | 20 | 70 | 50 | 47.9 | 15.1 | local market | 48 |
| **Amaranthus** | kg | 15 | 20 | 60 | 20 | 25.0 | 11.2 | barter value | 25 |
| | pathi | 16 | 100 | 200 | 150 | 151.9 | 42.3 | barter value | 34 |
| **Gourd** | kg | 58 | 10 | 50 | 20 | 22.7 | 8.8 | barter value | 23 |
| **Pumpkin** | kg | 28 | 10 | 50 | 20 | 27.5 | 13.0 | barter value | 27 |
| | piece | 33 | 15 | 70 | 40 | 38.3 | 11.8 | barter value | 19 |
| **Radish/turnip** | kg | 217 | 10 | 30 | 15 | 16.9 | 4.8 | barter value | 17 |
| **Tree tomato** | kg | 13 | 20 | 65 | 60 | 52.7 | 13.3 | barter value | 52 |
| **III. Livestock products** | | | | | | | | | |
| **Butter** | kg | 8 | 200 | 300 | 275 | 266.3 | 38.9 | local market | 266 |
| **Cheese** | kg | 12 | 200 | 350 | 275 | 270.8 | 62.0 | local market | 270 |
| **Egg** | piece | 608 | 10 | 15 | 10 | 10.0 | 0.2 | local market | 200 |
| **Ghee** | kg | 17 | 300 | 600 | 350 | 370.6 | 101.6 | local market | 370 |
| | mana | 61 | 150 | 400 | 300 | 286.4 | 42.3 | local market | 573 |
| **Hide/skin** | piece | 117 | 10 | 1500 | 50 | 75.1 | 150.6 | local market | - |
| **Honey** | mana | 66 | 200 | 350 | 300 | 304.2 | 22.3 | local market | 608 |
| **Meat chicken** | kg | 309 | 120 | 800 | 300 | 316.7 | 96.6 | local market | 316 |
| **Meat mutton** | kg | 220 | 100 | 500 | 200 | 204.7 | 67.7 | local market | 205 |
| **Meat pig** | kg | 6 | 100 | 200 | 160 | 161.7 | 37.1 | local market | 162 |
| **Meat yak** | kg | 12 | 100 | 500 | 200 | 220.8 | 119.6 | local market | 221 |
| **Milk** | litre | 78 | 40 | 90 | 55 | 55.6 | 12.0 | local market | 55(/l) |
| | mana | 145 | 10 | 40 | 25 | 26.7 | 5.7 | local market | 53(/l) |
| **Wool** | kg | 22 | 10 | 70 | 27.5 | 29.5 | 17.2 | local market | 30 |

| Products | Local unit | n | Min | Max | Median | Mean | s.d. | Valuation method | Nr/kg[1] |
|---|---|---|---|---|---|---|---|---|---|
| **Beehive** | piece | 128 | 300 | 6500 | 1000 | 1384 | 1140 | local market | - |
| **Buffalo** | piece | 84 | 3000 | 25000 | 16000 | 15464 | 5687 | local market | 77 |
| **Chicken** | piece | 828 | 200 | 1200 | 600 | 623.9 | 160.5 | local market | 312 |
| **Cow** | piece | 476 | 300 | 35000 | 1200 | 1888.9 | 3658.6 | local market | 9 |
| **Dog** | piece | 221 | 100 | 2000 | 400 | 429.6 | 186.8 | local market | 43 |
| **Duck** | piece | 8 | 200 | 800 | 500 | 518.8 | 239.0 | local market | 259 |
| **Goat** | piece | 237 | 800 | 5000 | 2000 | 2209.9 | 813.3 | local market | 110 |
| **Horse** | piece | 120 | 15000 | 100000 | 35000 | 39220 | 17389 | local market | 196 |
| **Mule** | piece | 77 | 15000 | 45000 | 30000 | 30701.3 | 4199.2 | local market | 154 |
| **Ox** | piece | 529 | 1500 | 8000 | 5500 | 5174.9 | 1086.2 | local market | 26 |
| **Pigeon** | piece | 16 | 100 | 350 | 150 | 161.3 | 57.5 | local market | 269 |
| **Pig** | piece | 30 | 1500 | 15000 | 5000 | 6683.3 | 3902.9 | local market | 134 |
| **Sheep** | piece | 129 | 1100 | 7000 | 3000 | 2948.3 | 783.8 | local market | 147 |
| **Yak** | piece | 20 | 4000 | 40000 | 18000 | 20150 | 8362.0 | local market | 101 |
| **Mule carrier** | days | 6 | 150 | 600 | 300 | 316.7 | 150.6 | local market | - |
| **Horse riding** | days | 48 | 100 | 1500 | 500 | 517.7 | 268.5 | distant market | - |
| **Draught power** | days | 350 | 100 | 600 | 300 | 257.9 | 73.7 | value of time | - |
| **Manure**[2] | bhari | 29 | 25 | 60 | 30 | 37.4 | 13.9 | value of time | 1 |
| | doko | 548 | 15 | 150 | 50 | 43.3 | 17.8 | value of time | 2 |

[1] These figures should be treated with caution: the most reliable are those where local units have been weighed in SI units (see Table 2 for products with $n > 5$). Other rely on respondent guesstimates or, more rarely, figures from the literature.

[2] The value of composted manure can be calculated as the sum of dry pine needle litter and manure.

**Table 4** Seasonal variation in own-reported values (Nr) for selected forest products (with high number of observations), Lower Mustang District, 2006

| Products | Local unit | N | Winter | | | Spring | | | Summer | | | Autumn | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | n | Mean | s.d. | n | Mean | s.d. | n | Mean | s.d. | n | Mean | s.d. |
| **Bamboo** | bhari | 283 | 69 | 193 | 67 | 59 | 282 | 80 | 94 | 319 | 51 | 61 | 288 | 75 |
| **Charcoal** | bora | 148 | 73 | 111 | 27 | 24 | 105 | 21 | 22 | 110 | 18 | 29 | 139 | 32 |
| **Bamboo basket (doko)** | piece | 111 | 2 | 103 | 25 | 41 | 95 | 17 | 45 | 90 | 15 | 23 | 97 | 11 |
| **Fodder grass (ordinary)** | bhari | 42 | 21 | 74 | 23 | 3 | 50 | 0 | 10 | 75 | 27 | 8 | 74 | 33 |
| | mutha | 201 | 14 | 17 | 10 | 59 | 20 | 7 | 84 | 10 | 6 | 44 | 10 | 7 |
| **Fuelwood (trunk)** | bhari | 562 | 230 | 81 | 26 | 96 | 70 | 8 | 66 | 81 | 38 | 170 | 82 | 16 |
| **Fuelwood (twig/branch)** | bhari | 283 | 113 | 71 | 38 | 40 | 55 | 16 | 24 | 135 | 93 | 106 | 60 | 16 |
| **Compost manure** | doko | 444 | 108 | 35 | 12 | 102 | 45 | 14 | 119 | 49 | 9 | 115 | 53 | 24 |
| **Mushroom (tawe)** | pathi | 59 | NA | NA | NA | 4 | 300 | 0 | 52 | 297 | 21 | 2 | 325 | 35 |
| **Poles** | piece | 108 | 37 | 102 | 103 | 37 | 84 | 110 | 26 | 55 | 68 | 8 | 135 | 127 |
| **Leaf litter (sanpat)** | bhari | 234 | 137 | 66 | 20 | 9 | 94 | 81 | NA | NA | NA | 88 | 101 | 17 |
| **Wooden stick (tayu)** | piece | 195 | 61 | 10 | 5 | 55 | 7 | 3 | 61 | 7 | 6 | 18 | 16 | 4 |

Thus the results in Table 3 indicate that valid and reliable own-reported values, also for forest and non-forest environmental products that are not traded or bartered, can be established using the described valuation methods and that these values can be interpreted in an economic sense as prices. Such values can thus be used in forest income calculations for households where own-reported estimates are not available.

When estimating the opportunity cost of labour, it should be noted that labour wage rates vary across seasons and gender. An overview of these variations is presented in Table 5. There is a tendency for wage rates to be higher during the summer (main harvest season) and lower during the winter but this is not statistically significant. There is also a tendency for male wage rates to be higher than female wage rates but again the differences are not significant.

**Table 5** Farm and non-farm labour wage rate (Nr/day±s.d. / *n*) variation across seasons and gender, Lower Mustang District, 2006

| | Sex | Winter | Spring | Summer | Autumn | Mean |
|---|---|---|---|---|---|---|
| **Farm** | Female | 185±41 / 6 | 208±34 / 30 | 205±44 / 22 | 220±49 / 25 | 209±43 / 83 |
| | Male | 188±48 / 14 | 209±48 / 29 | 251±76 / 18 | 238±64 /12 | 220±62 / 73 |
| **Non-farm** | Female | 189±45 / 19 | 221±92 / 11 | 272±91 / 11 | 236±70 / 11 | 223±77 / 52 |
| | Male | 290±125 / 31 | 364±148 / 27 | 335±64 / 35 | 292±70 / 31 | 319±108 /124 |
| **Mean** | | 233±102 / 70 | 253±112 / 97 | 276±84 / 86 | 253±70 / 79 | 255±95 / 332 |

## 3.3 Techniques used to estimate values for difficult products

The majority of products making up household income can be valued using interviewees own-reported values. In most cases, valuation is straight forward, e.g. (i) lumber of *Pinus wallichiana* are purchased from the local saw mill for Nr 180/cuft and this is used as the farm-gate price for this product, or (ii) some wild mushrooms and wild vegetables have close substitutes, such as cultivated vegetables, with a local market price. However, there are products for which valuation is difficult. In the following, an overview is provided of how valuation was done for products that are neither traded or bartered and where there are no useful substitutes on which to base valuation**.**

***Fuelwood*** is usually collected on discrete harvesting trips (i.e. harvesting trips organised with this single purpose) during late autumn and winter and were hence valued using the opportunity cost of labour, taking into account gender and seasonal variations in daily wage rates (the average daily adult wage rate was Nr 255±95; Table 5). There is some variation in the resultant estimated values as there are variations in species harvested, distance to collection sites, and individual carrying capacity.

In the production systems in the study area, stall feeding is common. Manure is gathered from the stalls and mixed with dry pine needle litter and mixed leaf litter (the latter usually in smaller amounts) in composting pits. The composted manure is transported in dokos to agricultural fields and applied. The ***dry pine needle litter*** and ***mixed leaf litter*** is usually gathered in bharis during discrete collection trips, only allowed after the first flush of snow in late autumn or early winter, and valued using the opportunity cost of labour.

Likewise, ***manure*** is valued based on the time required to collect, transport and apply the composted manure using the opportunity cost of labour. The unit value of ***composted manure*** can thus be calculated as the sum of the unit value of litter and manure. There is some variation around the mean value for both litter and manure as collection distance and individual carrying capacity vary.

***Clay*** is excavated along river banks and used for roofing of houses. Again, as the excavation and transport are discrete activities, the opportunity cost of labour was used for valuation. Value variation is due to differences in physical performance of excavators/porters.

A few ***medicinal plant products*** are traded locally, and some are traded through long-established marketing chains and can be valued using prices at road heads (distant market prices). We had only very few observations of medicinal plants used for self-medication and it appears likely that this product group is significantly under-reported.

Livestock are critical to most households in the study area and most livestock products can be valued using farm-gate or barter pricing. The important exception is browse and graze. Most livestock feed freely in de facto community managed forest and grassland areas and the value of browse and graze is significant as these constitute the major source of fodder for cattle, buffaloes, horses, mules, goats, sheep and yak. Browse and graze are, however, difficult to value as there is no market for grazing rights and no close substitutes. Cavendish (2002) discusses the possibilities of valuing livestock feed at the output end but this requires a string of assumptions, e.g. that livestock do not add value to food inputs, that makes these approaches very questionable. Instead, we here present an alternative approach that focus on directly valuing browse and graze at the input end. First, using Nepal specific data, we estimate annual fodder consumption per livestock unit; then, using data from our structured survey, we determine the relative importance of main land use types as sources of fodder; finally we combine this with the valuation of ordinary quality fodder grass, that can be estimated using the opportunity cost of labour, to arrive at the total value of fodder per household (approach can also be used to calculate the total value of fodder per land use type).

The daily per livestock unit (LU, equivalent to adult cow weighing 200 kg) feed requirement is 4.8 kg dry weight: 17 kg fresh weight/day, with browsing and grazing animals consuming 70% of this (enough to meet minimal maintenance requirement, ensure limited milk production and provision of draught power), and dry/wet weight ratio of 0.4 (Metz 1994). This figure is close to the minimal subsistence annual fodder demand of 1.7 t (oven-dry weight) per LU per year estimated by Mahat et al. (1987).

A seasonal overview of the relative importance of sources of fodder in the study area is provided in Table 6. There is some stall feeding of livestock, especially during the winter, but the majority of fodder (82%) is obtained through browsing and grazing. In Chimkhola, neighbouring the present study area, Metz (1994) similarly estimated that browse and grazing provided around 70% of livestock fodder. In our study area, forests are the single most important source of fodder (55% of total), followed by grass land (21%) and agricultural land (15%), Table 6. It is also noteworthy that forests are important throughout the year while grass lands are mainly important in the summer and autumn and agricultural land in the winter (livestock graze directly on fields when there are no crops) which is also when stall feeding is most important. Livestock is consequently moved between alpine pastures (grass lands) and valley bottoms (agricultural land). Most fodder used in stall feeding is derived from agricultural land (67%), i.e. agricultural residues (trees are not found on agricultural land in the study area), and forests (23%).

**Table 6** Relative importance (%) of sources of livestock fodder across seasons and the relative importance of browse/graze and stall feeding across seasons and sources of fodder, Lower Mustang District, 2006. Based on quarterly interviews with 164 livestock owning households

| | Agriculture | Forest | Grass land | Other land | Browse and graze | Stall feeding |
|---|---|---|---|---|---|---|
| **Winter** | 34 | 50 | 5 | 11 | 67 | 33 |
| **Spring** | 12 | 55 | 13 | 20 | 87 | 13 |
| **Summer** | 12 | 63 | 24 | 2 | 91 | 9 |
| **Autumn** | 1 | 53 | 44 | 2 | 85 | 15 |
| **Full year** | **15** | **55** | **21** | **9** | **82** | **18** |
| **Browse and graze** | 4 | 62 | 24 | 10 | | |
| **Stall feeding** | 67 | 23 | 8 | 3 | | |
| **Avg value of browse and graze (Nr/hh)** | 1833 | 6721 | 2566 | 1100 | 10020 | 2200 |

***Fodder grass*** (sanchi) is harvested and stored in small semi-dry twisted bundles (mutha). High quality grass has a local market price as it is purchased by mule owners (transporting goods through the area using so-called mule trains). Ordinary quality grass is usually collected on discrete harvesting trips for use in stall feeding and can thus be valued using the opportunity cost of labour. Thus the value of ***browse and graze*** can be calculated, using the figures for weight and values in Tables 2 and 3, to Nr 0.74 per dry weight kg (mean price of Nr 55.7 per bhari ordinary quality grass weighing 30.3 kg of green weight converted to dry weight using the dry/wet weight ratio of 0.4). This can then be used to estimate the total value of livestock browse and graze per household (as well as per source of fodder, such as forests). When calculating per household income, the value of browse, graze and stall feed should be deducted from livestock income and booked under the sources of fodder.

## 4. Discussion and conclusion

Households in the Central Himalaya use a large number of products, for both commercial and subsistence purposes, harvested across land use types in the landscape. The majority of products can be valuated using farm-gate or barter prices or through valuation of a close substitute with a local market price. Analysis of basic distributional statistics for such prices, generated through own-reported values by interviewed households, show that prices are valid and reliable across very different product types. It was also attempted to standardise local units for the major forest and agricultural products; this work is very time consuming and for some products it seems that the number of observations need to be increased as there may be substantial variation in weight, e.g. due to differences in moisture content or species composition.

Products that are neither traded nor bartered and where there are no useful substitutes on which to base valuation are more difficult to value. Fortunately, in this study area, most of the major products were collected during discrete harvest trips and it was straight forward to estimate the opportunity cost of labour. One particularly challenging product to value was browse and graze; livestock income is important to most households in the study area and, to get an accurate picture of the relative importance of different sources of subsistence and cash income, it is important to estimate the value of fodder inputs. By combining already available data on livestock unit feed requirements with data collected on sources of fodder and valuation of fodder grass, using the opportunity cost of labour, it was possible to estimate the value of browse and graze as well as stall feeding.

In conclusion, we found it reasonable to use households own-reported values as these estimates produced aggregated unit values with acceptable properties.

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# Who gains or who loses from Joint Forest Management? Lessons from two case study areas from Andhra Pradesh, India

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## Abstract

In 1990, the government of India issued a national guideline to all states to adopt Joint Forest Management (JFM) to achieve better resource conservation through partnerships between Forest Department (FD) and Forest Protection Committee (FPC)s which consists of local villagers. While JFM has also been viewed as a means to improve the livelihood of the forest dependent, several uncertainties and questions remain. First, it is not clear how such institutionally defined FPC can gain from JFM. Secondly, it is not clear whether FPC are in effect facilitating equitable distribution of benefits from forest related activities. Finally it is not clear what consequences the process of formalizing local institutional units and defining their forest boundaries may have at the local level benefit destribution from forests. This paper thus aims to further understanding of "who gains and who loses from JFM" based on an empirical investigation of two case study areas from the Khammam and Medak districts of the Andhra Pradesh state, India. The paper firstly analyzes local level processes involved in JFM and changes in the way in which concerned local actors access to direct and indirect benefits derived from forest related activities.

**Key words**: Joint Forest Management, Decentralization, Property and Access

## Background

Over the last decades, a prominent trend has been within the forest sector in developing countries, to shift from centralized, top down towards more local based inclusive forest management approaches including in India.

Until late 1980s, national forest policies in India had been characterized with the top down approach, which was mainly led by the state's interest to maximize economic revenue from forests under their ownership. In many parts of India, as shown in Table 1, the relationship between the Forest Department (FD) officers and local villagers was the one between those regulate and those subject to regulations. The FD officers, being sole official managers of forests, had exclusive property rights to forest resources and lands and exercised policing power over local villagers. Local villagers, who had no official rights or roles to use or manage forest resources, were often identified by the FD as illegal encroachers or offenders to forests and were forced to pay fines, permission fees, or bribes to the FD. In spite of the presence of such regulations, however, most of those locals had *de facto access* to forest resources, entering forests by carefully avoiding the timings and places of the FD officer's patrols. Thus, it was a more or less "open access" situation where all villagers access to forest resources in nearby forests.

**Table 1 Roles, responsibilities, and property rights related to forests before JFM**

| | | **Forest Department** | **Villagers and others** |
|---|---|---|---|
| **Roles** | | • Regulators of intruders to forests (with a policing authority)<br>• Manager of forests with a primary focus on plantation | **No** |
| **Responsibilities** | | • Protection and management of forests | **No** |
| **Property rights** | **Forest resources** | • Exclusive property rights to forest lands and resources | **No** |
| | **Revenue from forest related activities** | • Exclusive property rights to revenues generated from forest lands under their jurisdiction | **No** |

In 1988, the new national forest policy showed a drastic shift in terms of policy objectives, which placed higher priorities on forest conservation rather than maximization of revenue from forests. The policy also gave the first official recognition of the importance of incorporating the needs of local people in governing forests. Following the policy, the Ministry of the Environment and Forests issued a guideline to all states in 1990 to adopt Joint Forest Management (JFM). The objective of JFM is to achieve better resources conservation through partnerships between Forest Department (FD) and Forest Protection Committee (FPC)s which are consisted of local villagers (Khare et al 2000). The new way of governing forests is mainly concerned with achieving both forest conservation and meeting the livelihood needs of those who dependent on forests through engaging them in protection and scientific management of forests.

The introduction of the JFM approach has brought about numerous changes with regard to roles, responsibilities and property rights of the FD and FPC as shown in

Table 2. JFM led to reconfiguration of local level relationships and through integrating local villagers, who used to be informal local actors, into a formal, regulatory forest governance system (Agrawal 2005).

**Table 2 Roles, responsibilities, property rights in the case of Andhra Pradesh state under JFM (based on Gorvernment t Order 2002)**

| | | **Forest Department** | **Forest Protection Committees (FPCs)** | **Others** |
|---|---|---|---|---|
| **Roles** | | • Co-manager<br>• Facilitator for the FPC | • Co-manager of forests | No |
| **Responsibilities** | | • Forest protection<br>• Forest improvement | • Forest protection<br>• Forest improvement | No |
| **Property rights** | **Forest resources** | • Forest lands | • Usefructory rights of NTFPs, fuelwood etc<br>• Rights to sell some products to an open market<br>• Rights to sell incremental volume of timber in their territories | No |
| | **Revenue from forest related activities** | | • **50 % of fines** collected from forest offenders<br>• **Wage**s from forest improvement<br>• **Other revenues** generated from forest related activities | No |

The role of local villagers changed to co-manager of forests with the Forest Department (FD) officers as a facilitator. In general, JFM facilitates institutional recognition, which refers to a choice of institutions by government or internal agencies to serve specific purposes (Ribot 2007).

The process of institutional recognition involves demarcation of forest boundary, grouping of villagers, to constitute Forest Protection Committees (FPCs) and selection of Management Committee and a chairperson. FPC members are assigned responsibilities to protect forests against encroachment, grazing, fires and thefts of forest produce, and to engage in forest improvement activities such as soil moisture conservation, scientific forest management and plantation,. In order to facilitate such FPC activities, a micro plan was introduced as a planning tool for each FPC. Each FPC has to prepare a micro plan in order to make decisions and rules for how to govern demarcated forests and to implement these decisions in collaboration with the FD officers. Management Committee and its chairperson/vice chairperson have responsibilities to monitor and implement the works according to the micro plan. The facilitation of FPCs also involves meetings to prepare and review implementation progress of the micro-plan, recording of minutes and management of accounts accruing from JFM related activities. In return for these responsibilities, villagers who participate in the FPC gain property rights to some forest resources within the demarcated forests for domestic use and sale. While benefit sharing arrangements for forest resources vary from state to state, in the case of the Andhra Pradesh state, all the households in the FPC gain usufruct rights over forest resources such as fuelwood and Non Timber Forest Products, and 100 % of the incremental volume of timber and bamboo harvested from the FPCs' forest. In addition, FPC members are entitled to receive wages if they participate in forest improvement works, and to receive 50 % of fines if they hand over forest offenders to the FD.

Since inception, the number of JFM FPCs has shown an exponential growth supported with donor support from the World Bank, the Japanese Bank for International Cooperation and DFID. As of 2006, 27 percent of Indian forests (17.3 million hectares of forest land) are reserved for 85,000 JFM FPCs (World Bank 2006). Despite such proliferation of the JFM approaches across India, increasing concerns have been raised over whether the introduction of JFM contributes to equitable distribution of benefits among local actors at several levels.

First of all, it is not clear to what extent such institutionally defined FPC may benefit from JFM. It is not certain to what extent previously existed asymmetric power relationship between villagers and the FD may change after JFM, or to what extent villagers in FPCs can influence and share control over the processes vis-à-vis the FD. Despite all the rhetoric of sharing power between the government and local people through "partnership", however, many empirical examples suggest that local villagers have been used as a tool for protecting and conserving forests rather than a partner (Khare et al 2000; Poffenberger 2000; Hildyard et al, 2001, Sarin et al 2003, ).

Secondly, it is not clear whether and to what extent FPCs are in effect facilitating equitable distribution of benefits from JFM. The size of local units varies from location to location and they are often highly heterogeneous comprised of multiple actors with different interests and norms (Agrawal and Gibson 1999, Campbell et al, 2001). This variability and complexity may have different consequences for both processes and consequences of JFM. Particular concern has been the issue of "elite capture" which refers to situations where members of elite groups dominate decision making processes, and improve their access to benefits from forest related activities while marginalizing the socially disadvantaged groups (e.g. the poor, women) (Agarwal 2001, Kumar 2002).

Finally, it is not clear what consequences the process of formalizing local institutional units and defining their forest boundaries may have at the local level. This may increase power to those officially included in the units and result in the exclusion of other unauthorized users and disable their access to forest resources for subsistence use and income (Carter and Gronow 2005). Defining boundaries may have adverse impacts particularly in the forest resource scarce area where many forest users may contest their access to scarce forest resources.

This paper aims to investigage effects of JFM on distribution of benefits from forest related activities at the local level based on a detailed empirical investigation and to highlight underlining mechanisms for benefit distirubiton. The main focus will be on how the introduction of JFM changes ways in which local actors such as forest department officials, Forest Protections Committees, its members, and other local level forest users, gain or lose benefits from forest related activities.

## Analytic framework and approaches

In order to analyze changes in benefit distribution at various levels, the paper will apply the concept of "access" as defined by Ribot and Peluso (2003). According to their definition, access refers to the ability to derive benefits from things while they view property as the right to benefits. In other words, whereas property lays out rules for how local actors may obtain and make use of benefits from particular resources and activities, access shows actual consequence of how rules are translated into practice through local level processes where various local actors interact with one another.

The paper aims to make visible actual effects of the JFM on the ability of local actors to benefit from forest related activities through focus on changes in accesses based on a case study. But also it attempts to highlight mechanisms for how such effects came about through analyzing local level processes involved in forest management. The empirical case study analysis consists of two main parts. The first part focuses on local level processes, which include processes of institutional recognition of forest boundary and constitution of the FPC, and making and implementation of decisions and rules for how to protect, and improve their designated forests. The second part of the case study analysis will describe changes in access at three different levels, between the FD and FPCs, within FPC members and within villages. Main local actors in question include the Forest Department officials, Forest Protection Committee (FPC), individual members of the FPCs with different castes and gender and other local forest users in close vicinity such as neighboring villagers and illegal loggers. Benefits include direct benefits from forest resources such as fuelwood, timber and key Non Timber Forest Products (NTFPs) and indirect benefits which accrue from forest related activities such as bribes, wage employment, fines and user fees.

## Introducing the case study area

The study area, the Andhra Pradesh (AP) state, is the fifth largest state which has a population of 76.2 million (Census 2001). It has 6.4 million hectares of forestland, which constitutes 23% of the state's geographical area and 8.24 % of the total Indian forest area (Andhra Pradesh Forest Department 2006). Since 1992, the Andhra Pradesh Forest Department have implemented the JFM program, which has also been financially supported with the World Bank funding for JFM Project from 1994 to 2000 (USD77,4 million) and Community Forestry Management Project from 2002 onwards (USD 108 million). The number of FPCs in Andhra Pradesh amounts to 8,343 in total as of May, 2006 (Andhra Pradesh Forest Department 2006). About 1.5 million ha of forests (25% of total forests in AP) is managed by the FPCs under JFM (ibid).

Within the AP state, the author purposefully selected the Khammam district, which is a forest dense area, with 52.6 % of forest area, and the Medak district, which is a forest scarce area with 9.4 % of forests. Furthermore, two villages (Venkampalem and Buruguwada villages), from the Khammam district, and two villages (Mahmad Nagar and Thimmapur villages) from the Medak district were selected. The two case study areas differ in terms of degree of forest abundance, size of villages, and caste composition (see Table 3). The selection was based on the assumption that such differences may have different impacts on accesses of concerned local actors to benefits from forest related activities.

The Venkampalem and Buruguwada villages in the Khammam district are relatively small with 38 and 41 households, respectively, homogenous with only one caste group (Koya tribe) and endowed with larger forest areas per household with 13.2 ha and 5.5 ha of forests per household respectively. The villages are located in a tribal belt within forest dense area, where Koya tribe is a dominant population. This area has been also susceptible to high incidents of illegal logging, as there are many high valued timbers such as teak and rosewood.

**Table 3 Characteristics of selected villages for a case study**

| **District** | **Khammam** | **Khammam** | **Medak** | **Medak** |
|---|---|---|---|---|
| **Name of village** | **Venkampalem** | **Buruguwada** | **Mahmad Nagar** | **Thimmapur** |
| **Year of establishment** | **1998** | **1998** | **1997** | **1998** |
| **Allotted forest lands (ha)** | **500** | **225** | **574** | **372** |
| **Number of households** | **38** | **41** | **325** | **344** |
| **Forest ha per household (ha)** | **13.2** | **5.5** | **1.8** | **1.1** |
| **Other Caste** | | | **10%** | **4%** |
| **Backward Caste** | | | **37%** | **39%** |
| **Scheduled Caste** | | | **17%** | **14%** |
| **Scheduled Tribe** | **100 % (Koya tribe)** | **100 % (Koya tribe)** | **36% (Lambada tribe)** | **43% (Lambada tribe)** |

In contrast, the Mahmad Nagar and Thimmapur villages are relatively large with 325 and 344 households respectively, heterogeneous with four caste groups, and endowed with small forest area, 1.8 ha and 1.1 ha of forest per household respectively. The villages are located within scattered forests. These villages are heterogeneous consisted of four caste groups, namely, the highest ranked, Other Castes, the second highest ranked, Backward Caste, Schedule Caste, and Scheduled Tribe. They are commonly used categories in the rural parts of Andhra Pradesh state and Scheduled Caste and Scheduled Tribe are generally known to be socially disadvantaged groups.

## Methods

The field research in the study areas was conducted for four months during the period between May, 2005 and January, 2008. The first phase field work concentrated on qualitative methods. The author conducted semi structured interviews and focus group discussions with around 100 villagers from the Khammam and Medak districts to gain in-depth understanding of their perspectives on changes in access to forest derived benefits. The informants included chairpersons, Management Committee and general members of FPCs as well as a village political representative, making sure to include those with different socio economic background such as caste groups, main livelihood occupation (e.g. agriculturist, NTFP collectors, livestock holders, and wage labor) and gender (male and female). Based on the results of qualitative interview, questionnaire surveys were conducted with 330 villagers to gain quantifiable indicators. In addition, semi-structured interviews were conducted with Additional Principal Chief Conservator of Forests, District Forest Officers (DFO), Forest Range Officers, Forest Section Officers, Forest Beat Officers (FBO) in study areas and both state and grass root level NGOs.

## Case study 1

In the case of Venkampalem and Buruguwada FPCs in the Khammam district, the local level processes were characterized with both the FD's domination as well as FPC's low interest in FPC activities. The FD dominated in most of the local level processes, from institutional recognition, to making and implementation decisions with minimal involvement of FPCs as shown in Table 4.

**Table 4. Level of involvement of Forest Department (FD), Forest Protection Committee (FPC)s, and NGOs in local level processes in the Khammam district study area**

| | FD | FPC | NGOs |
|---|---|---|---|
| **1. Institutional recognition** | | | |
| **1.1. Boundary demarcation** | ◎ | | |
| **1.2. FPC constitution** | ◎ | ○ | ○ |
| **1.3. Selection of representatives** | ◎ | ○ | ○ |
| **2. Making decisions and rules** | | | |
| **2.1. Micro plan (forest improvement)** | ◎ | △ | ○ |
| **2.2. Forest protection** | N.A | N.A | N.A |
| **2.3. Internal rules over use of forests** | N.A | N.A | N.A |
| **3. Implementation of decisions and rules** | | | |

| | | | |
|---|---|---|---|
| **3.1. Micro plan (forest improvement)** | ◎ | △ | ○ |
| **3.2. Forest protection** | **N.A** | **N.A** | **N.A** |
| **3.3. Internal rules over use of forests** | **N.A** | **N.A** | **N.A** |
| **3.4. Facilitation of FPC activities** | | | |
| ***3.4.1. FPC meetings*** | ◎ | △ | |
| ***3.4.2. Recording of minutes*** | ◎ | | ○ |
| ***3.4.3. Account management*** | ◎ | △ | |
| ***3.4.4. Sanction of violators*** | ◎ | | |
| ***3.4.5. Re-election of representative*** | ○ | ◎ | |

**◎----high level of involvement**
**○----some level of involvement**
**△----minimal level of involvement**

The FD demarcated forest boundary for both FPCs and designed a micro plan. The FD officer's also controlled FPC minutes and accounts which was supposed to be under the FPC's responsibility according to official rules. The processes of implementation of decisions and rules were characterized with low level of interest of FPC members. Except for several key elite members, general members and women showed little interest in participating in the FPC activities. Few attended meetings, and were engaged in forest protection activities.

There are several possible reasons for the FD's domination as well as FPC's low level of interest in FPC activities. First of all, since forest resources are abundant in the study area with little competition among local actors for forests, there was less incentive for FPC members to exclude others from accessing forests through forest protection which was promoted by JFM. Another reason is related to the FD's reluctance or resistance to let go power to FPCs or to actively support FPC activities. In both FPCs, neither FD nor NGOs have provided trainings to raise FPC's members' awareness about roles, responsibilities, and rights or to build or enhance FPC's capacity to prepare micro plans, manage minutes and accounts. The FD officers also showed lack of accountability towards the FPC members. The FD made a micro plan without incorporating needs of the FPC members. The FD field level officers obscured wage payment processes for forest improvement activities by taking some portion of wages into FD's pockets with the result that only minimal wage payments were made to FPCs. The FD did not either provide any backup enforcement for FPC's forest protection activities: the FD never paid to the FPCs, share of fines collected from forest offenders which FPC apprehended to the FD even though FPCs are entitled to such fines according to official rules. This lack of support from and accountability of the FD towards FPCs resulted in a failure in building genuine "partnership" between the FD and FPCs and further discouraged FPC members to actively engage in FPC activities. Because no payment of fines is made to FPC, FPC also stopped protecting forests against others at the beginning stage. At the same time, the FD's domination may also be due to characteristics of FPCs. Both FPCs are relatively small with approximately 40 households with only a few educated. The small sizes of villages with only a few educated posed practical obstacles for FPCs to claim their rights and to prepare a technically complex lengthy micro plan, to write minutes and to manage accounts.

With regard to who benefits or who loses from JFM in the Khammam study area, Table 5 summarizes changes in accesses of local actors to benefits derived forest related activities.

As for access of the Forest Department (FD) to forest derived benefits, whereas the FD lost their access to bribes from villagers, they gained access to new kinds of indirect benefits from forest improvement activities through taking some portion of claimed wages supposed to be paid for the FPC into their own benefits.

On the other hand, the domination of the FD and little participation of FPCs resulted in limited benefits for the FPC. No mechanisms have been in place to regulate access to forests in the area due to no forest protection activities, which led to constant decline of forest resources. Revenue from plantation is yet to come as they have not matured. Benefits that FPC gained from JFM area were therefore limited to reduction of bribe amounts to the FD, and minimal wage payment which the FPC gained through forest improvement activities. This raised a question whether FPCs in this study area benefit from JFM, which gives a rise to high transaction costs through making micro plans, execution of forest improvement activities, conducting of numerous meetings, and recording of minutes and accounts. This situation also poses a question for sustainability of the JFM activities in the long run in particular when the wage payment runs out after the completion of the World Bank project.

**Table 5 Changes in access of local actors to forest derived benefits in the Khammam district study area**

| | | **FD** | **2 FPCs** | **Neighboring villagers** | **Illegal loggers** |
|---|---|---|---|---|---|
| **Forest resources** | Fuelwood | - | Little change | Little change | - |

| | | | | | |
|---|---|---|---|---|---|
| | Timber | - | Little change but additional profits may come from plantation | Little change | Little change |
| | Bamboo | - | Little change but profits may come from plantation in the future | Little change | - |
| | Fodder | - | Little change | Little change | - |
| | Beedi leaf | - | Little change | Little change | - |
| | Bloom stick | - | Little change | Little change | - |
| **Revenue generated from forest related activities** | Bribes | Decreased | Reduction of bribes to FD | - | - |
| | Wages for forest improvement | Some portions go back to the FD | Minimal wage payment (apx. USD1) | - | - |
| | Fines | Little change | No payment | - | - |
| | Collection fees | - | - | - | - |

With regard to impacts over other local actors, due to lack of forest protection activities by FPCs, little impacts on accesses were observed for neighboring villagers or illegal loggers, who neither lost nor gained from JFM as a result. Illegal logging thus remains to be a serious problem in the region.

## Case study 2

In contrast to the Khammam district study area, the Medak district study area showed significantly different processes, characterized with the FPC's high sense of ownership in the FPC activities by taking an active role in many of local level processes related to forest management as shown in Table 6

**Table 6. Level of involvement of Forest Department (FD), Forest Protection Committee (FPC)s, and NGOs in local level processes in the Medak district study area**

| | FD | FPC | NGOs |
|---|---|---|---|
| **1. Institutional recognition** | | | |
| **1.1. Boundary demarcation** | ◎ | | |

| | | | |
|---|---|---|---|
| **1.2. FPC constitution** | ◎ | ◎ | ○ |
| **1.3. Selection of representatives** | ◎ | ◎ | ○ |
| **2. Making decisions and rules** | | | |
| **2.1. Micro plan (forest improvement)** | ◎ | △ | △ |
| **2.2. Forest protection** | | ◎ | |
| **2.3. Internal rules over use of forests** | | ◎ | |
| **3. Implementation of decisions and rules** | | | |
| **3.1. Micro plan (forest improvement)** | ◎ | ○ | △ |
| **3.2. Forest protection** | | ◎ | |
| **3.3. Internal rules over use of forests** | | ◎ | |
| **3.4. Facilitation of FPC activities** | | | |
| ***3.4.1. FPC meetings*** | △ | ◎ | △ |
| ***3.4.2. Recording of minutes*** | | ◎ | |
| ***3.4.3. Account management*** | | ◎ | |
| ***3.4.4. Sanction of violators*** | | ◎ | |
| ***3.4.5. Re-election of representative*** | △ | ◎ | △ |

**◎----high level of involvement**
**○----some level of roles**
**△----minimal level of involvement**

Both FPCs organized themselves to develop and implement their own rules, which also show FPC's high sense of ownership in FPC activities. One of possible reasons is the scarcity of and high competition among local actors for forest resources. This has given significant incentives for villagers to constitute FPCs to monopolize benefits from forest resource by excluding others' access to forests. In addition, a larger number of the educated in the village who can read and write, enabled FPCs to take control over processes of decision making and implementation of FPC activities. The larger sizes of the villages with approximately 200 to 300 households than in the Khammam study area may form another factor which could enable them to challenge the FD authority. It is also worth noting that a local NGO has provided an active support for FPCs to sensitize them about their roles, responsibilities and rights.

Nevertheless, the case shows significant differences between these two FPCs in terms of the processes of making and implementation of decisions and rules. The Mahmad Nagar FPC showed higher level of transparency and accountability towards general members than Thimmpur FPC except for women members in both cases. While Mahmad Nagar FPC included all the castes in decision making and information sharing, Thimmapur FPC included only a small group of members in the processes. The chairperson of the Thimmapur FPC withheld most of information such as minutes and account book without disclosing them to general members. Another difference between two FPCs is the degrees of effectiveness in the enforcement and sanctions of decisions and rules in accordance to agreed principles. The Mahmad Nagar FPC made sure that rules for forest protection and internal use of forests be properly enforced: they employed 2 forest watchers and involved own villagers for forest protection by providing 25 % of fines collected by forest offenders to those who catch them. They also made sure that violators of rules be sanctioned according to rules regardless of castes, wealth, gender, or political affiliation. On the other hand, Thimmapur FPC employed solely 2 forest watchers without involving other villagers in forest protection. The chairperson also gave partiality to those who belong to the political party which he belonged to: he applied loose control over and sanction against those who belong to the same party as him and applied stricter control over and severe sanctions against those who belong to an opposing party. This non uniform enforcement and sanctions caused a serious conflict among those two parties, which led to collapse of the FPC management and the Thimmapur FPC has stopped since 2002.

With regard to who benefits or who loses from JFM in the Medak district study area,

Table 7 summarizes changes in accesses of local actors to benefits derived forest related activities.

**Table 7. Changes in access of local actors to forest derived benefits in the Medak district study area**

| | | FD | Mahmad nagar FPC | Thimmapur FPC | Neighboring villagers without FPC | Goat herders |
|---|---|---|---|---|---|---|
| Forest resources | Fuelwood | - | Increased | Decreased | Decreased | - |
| | Timber | Little | Increased | Decreased | Decreased | - |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | change | | | | |
| | Fodder | - | Little change | Decreased | Decreased | Decrease d |
| | Adda leaf | - | Increased | Little change | Little change | - |
| | Beedi leaf | - | Increased | Little change | - | - |
| | Bloom stick | - | Increased | Little change | - | - |
| Revenue generated from forest related activities | Bribes | Decreased | Reduction in bribes to the FD | Reduction in bribes to the FD | - | - |
| | Wages for forest improvem ent | Some portions go back to the FD | Minimal wage payment | Minimal wage payment | - | - |
| | Collection fees | Decreased | Some amounts from own villagers | - | - | - |
| | Fines | Decreased | Large amount of fines collected | No fines collected as of 2008 | Payment of large amounts of fine | Payment of large amounts of fine |

As for the FD, the way they benefit or lose from JFM is similar to the Khammam study area.

Regarding FPCs, the case showed a difference in these processes in making and implementation of decisions and rules between the two FPCs produced different effects in the way each FPC benefits or loses from JFM. The Mahmad Nagar's effective enforcement and sanctions of their decisions and rules resulted in regeneration of their forests. The FPC started to benefit from their exclusive and increased access to these resources. The FPC also gained new access to indirect benefits from forest related activities through collection of permission fee from own villagers and fines from violators both from inside and outside villagers. In the case of Thimmapur FPC, the loose enforcement and sanction of rules as well as collapse of the Thimmapur FPC caused a more or less open access situation in their forests: without control mechanisms over forest use, both own and outside villagers started to access to forest resources freely without any limits over collection amounts, which led to a rapid decline of available forest resources in their forests. As a result, the villagers did not gain either direct or indirect benefits from JFM.

With regard to benefit distribution among FPC members, while the Mahmad Nagar FPC as a whole gain from increase access to direct benefits from forest resources, indirect benefits which accrued to the FPC were not distributed in an equitable manner. For example, during the period between 1997 and 2002, the FPC collected a total of INR 164,861. This revenue was used to construct four Hindu temples in the main village. This excluded two types of caste groups in benefit distribution. Scheduled Cates (SCs) who used to be considered to be untouchable are not allowed to enter in these Hindu temples. Schedule Tribes (STs) who live in small hamlets outside the main village also feel excluded from accessing to these temples because of the distance to temples. Furthermore, while the same rules and restrictions on access to forest resources have been applied to everybody, these rules and restrictions were felt more among those who depend more on forests for their livelihoods. STs, for instance, consume more fuelwood than other castes and some groups of STs depend on wood cutting business, which require tree poles. Now that they have to pay permission fees beyond permitted amounts, it is difficult for them to sustain livelihood as before. As for gender impacts, while women are principal collectors of all forest resource, in both villages, women's participation in meetings is almost none due to social barriers. While a half of posts in the management committee is to be occupied by women according to official rules, their participation is nominal in practice as their husbands come to meetings instead. As a result, women's opinions are not fully reflected into decisions makings.

Furtheremore, the case of the Medak study area also shows potential detrimental effects of boundary demarcation of forests over equitable distribution of benefits in particular in a resource scarce area. In the Medak study area where forests are scarce, some villages received official recognition of their forests by the FD while others did not. This formalization of boundary and allocation of forests for particular villages has caused serious problems for some groups of villagers such as villagers without any official recognition of forests and herders of goats. Villagers without official recognition of forests started to lose from JFM because their access is blocked by other neighboring FPC villages and they are forced to pay a large amount of fines when caught. Many of herders of goats also lost from JFM as the boundary demarcation adversely impacted their livelihood. As they need to go beyond boundaries to feed their animals, they are frequently caught by neighboring FPCs and are forced to pay fines.

## Discussion

The case study results showed firstly that whether FPC as a whole benefit from JFM depends on numerous inter-related factors such as degree of villagers' interest in Forest Protection Committee (FPC) activities; degree of actual benefits which FPC gain as opposed to degree of transaction costs; degree of FPC's power that FPC can exercise making and implementation of decisions and rules; the FD's willingness to let go power to and to collaborate with FPCs, the degree of accountability and transparency of the FD in FPC management; degree of effectiveness of implementation by FPCs; the degree of accountability and transparency of Management Committees and chairperson of FPCs; and degree of support from a third party such as NGOs.

The two cases demonstrated the forest scarcity is one of key factors which trigger villager's interest to engage in FPC activities. Potential gains from excluding others are larger in the forest scarce area where resource competition is high, which may give significant incentives for villagers to organize themselves into FPCs. On the other hand, potential gains are likely to be smaller in resources abundant area. In this case, the degree of FPCs interest in FPC activities is likely to depend more on the degree of benefits which FPC gain from FPC activities in practice as opposed to transaction costs. In this regard, how much FPC can access to potentially large sources of revenues such as timber, plantation, wages from forest improvement activities, fines collected from forest offenders may become important factors. The degree of actual benefits that FPC gain also depends on several factors such as the degree to which FPCs can exercise their power in making of and implementation of these decisions and rules, the degree of FD's willingness to let go power to and to collaborate with FPCs, the degree of accountability and transparency of FD in designing plans and managing minutes and accounts, and proper enforcement of forest law through swift payment of fines to the FPC, the degree of effectiveness of implementation by the FPC. The effectiveness of internal enforcement and sanction depends on the quality and degree of accountability of chairpersons and management committee of the FPC towards the general members in sharing information and promoting transparency in account management. The presence of support from the third party such as NGOs to FPCs may also bring additional benefits to FPCs.

Secondly, the case study showed that whether JFM promotes equitable distribution of benefits among FPC members also depends on several inter linked factors such as degree of representation of management committee; degree of accountability of the chairperson and management committee towards general members; degree of involvement of different actors within FPCs in making and implementation of decisions and rules; the way in which rules affect different actors; and the way in which revenue is distributed.

Degree of representation in management committee will depend on whether chairpersons and management committees are democratically elected and whether the participation of the elected representatives is actually promoted in practice. Degree of accountability of chairpersons and management committee of the FPC towards the general members also affect benefit distribution among members. Degree of accountability can be measured in sharing information such as implementation progress and accounts to general publics, degree of enforcement of rules and sanctions which is in accordance to agreed principles without any partiality given to particular interest groups such as political parties. How affect different people rules is also an important factor which influences benefit distribution. Certain rules may adversely affect those who depend more on forests for their livelihood. For example, restrictions on collection of timber and fuelwood were felt more by wood cutters, and those who collect relatively more wood for their livelihoods. How benefits which accrued for FPCs is distributed also affect benefit distribution.

Finally, regarding who benefits or loses from JFM at the inter village level, the impacts on benefit distribution at the level depends on a combination of the factors such as degree of forest scarcity; the way in which forest boundary is demarcated and degree of forest protection measures applied by FPCs.

Whether JFM impacts access of neighboring villagers or illegal loggers largely depends on how strictly forest protection measures are enforced by a FPC. If forests are divided among certain groups of people, and if forest protection is well enforced in forest scarce area, the JFM may divide winners who can enjoy their access within the allotted forests and losers who lose access to benefits from forest resources as seen in the Medak case.

## Conclusion

Results of the case study have demonstrated that the same policies (property rights) under JFM have produced significantly different and diverse processes and effects at the local level. In other words, who benefits or who loses from JFM depends largely on both property rights as well as local level contexts such as characteristics of forest resources (e.g. scarcity, and value of forest resources) and characteristics and social and political relationships of local actors (e.g. FD, FPCs, NGOs, and other local actors). The presence of diverse impacts also highlights the critical need for policy implementers such as government, the forest department and donor agencies to carefully assess local contexts and to design implementation strategies which may better fit in local contexts to maximize positive effects and to mitigate negative effects.

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# Can we trust the data? Methodological experiences with forest product valuation in lowland Bolivia

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## Abstract

Forest products are important to rural households across virtually all forest types in developing countries. There are, however, only few comprehensive and systematic efforts at valuing these products and determining their absolute and relative economic importance to rural households. Having used the novel income survey approach developed by the global Poverty and Environment Network (PEN), this paper presents methodological experiences with forest product valuation in lowland Bolivia. Household ($n$ = 118) data was collected in six communities in the Tropics of Cochabamba from February 2006 to January 2007. Households used a large number of products, including 151 forest and non-forest environmental products. Valuing all these products was time consuming but possible using the households' own-reported values. Even for non-traded products useful values can be estimated. Generally, using household own-reported estimates result in aggregate unit values with satisfactory properties.

**Keywords**: Economic valuation, methods, Latin America

## 1. Introduction

Around 75% of the world's poorest people, the one billion persons living on less than USD 1 per day, live in rural areas (Scherr et al. 2004). There is evidence that forest products are harvested in significant quantities by these and better-off households across virtually all forest types in developing countries (Scoones et al. 1992, Pérez and Arnold 1996, Neumann and Hirsch 2000, Cunningham 2001). Frameworks have been developed for analysing and understanding different types of forest-dependency (Byron and Arnold 1999) and the continuum of forest-people interactions (Wiersum 1997). Research on the role and potential of forests in preventing and reducing poverty is, however, very limited and can be considered an emerging field of inquiry. A few recent case studies indicate that the normally "invisible" forest and environmental incomes can make up a substantial part of rural household incomes. Cavendish (2000), in his path-breaking investigation in rural Zimbabwe, found that more than 20% of rural household income was derived from forest and environmental resources, with this share almost doubling for the poorest households. A similar level of forest-dependence and variation in dependence across wealth groups was found by Campbell et al. (2002). In a meta-analysis of 54 case studies, Vedeld et al. (2004) found that on average 22% of the sampled households' income was derived from forest and environmental resources. They also found that forest income had a strong and significantly equalising effect on local income distribution. However, comparing the existing heterogeneous forest valuation studies is very challenging (Wollenberg and Nawir 1998, Sheil and Wunder 2002, Vedeld et al. 2004). In order to be able to assess the role of forests and other environmental resources in rural livelihoods, the Poverty and Environment Network (PEN) recently developed uniform, best-practice methods for systematic collection of household-level income data (PEN prototype questionnaire 2007, PEN technical guidelines 2007). The present study used these methods. This paper reports methodological findings, using the PEN prototype questionnaire and approach, on forest product valuation in a lowland rainforest site in Eastern Bolivia. The emphasis is on investigating whether own-reported value data is valid and reliable (and thus useful in estimating household incomes); this includes an explicit description of how main products were valuated.

### 1.1 Case study area

Field work was undertaken in the Tropics of Cochabamba, a 39,560 km² area making up 58% of the Department of Cochabamba (covering five municipalities) in the Eastern Bolivian lowlands. Annual rainfall is 5573 mm and annual average temperature is 25° C. The study area has a population of 146,921 (INE 2001) of which 17% is found in seven urban areas and the remaining scattered across more than 1000 usually small villages, composed of indigenous groups, such as Yuracare, Yuqui and Mojenos, and in-migrants from the Bolivian highlands. The lowest legally recognised administrative unit is the *sindicato*, usually compromising only one or a few communities, that are organised in *centrales* that are again organised in *federationes*; there are six federationes, 86 centrales and more than 760 sindicatos (UMSS-PROGEO 2005) in the Department of

Cochabamba. Indigenous communities, in addition, are organised in councils.

Land use is dominated by natural forests (67%), followed by agriculture and pasture lands (22%) with the remaining parts made up of rivers, roads (both important for transport) and settlements (11%). Agriculture is important in livelihood strategies; soils are generally poor; main subsistence crops are rice, maize and cassava; main commercial crops are coca leaves and fruits (citrus, plantain and cocoa). It is legal for farmers to produce coca leaves on farm plots up to 1600 $m^2$/household; alternative crops, such as palm heart, pineapple, achiote (*Bixa orellana)*, coffee and camu-camu (*Myrciaria dubia*), are promoted by development agencies in the study area as is formal forest management (UMSS-PROGEO 2005). Following the introduction of the 1996 forest law in Bolivia, there has been a shift from traditional subsistence use to commercial use of forests in the study area. In 2005, there were around 64 villages with formally approved forest management plans (Proyecto Jatun Sach'a 2005); commercial timber harvesting extracts around 3 $m^3$/harvest/ha (Malky 2005); and an estimated 150,000 ha is under formal management (UMSS-PROGEO 2005). Due to demand for agricultural and pasture lands, deforestation in the Department of Cochabamba runs at approximately 10-15,000 ha/yr (Proyecto Agroforestal C-23). In general, the rural population in the study area is poor, with 88% living below the national poverty line and a human development index of 0.56 (UDAPE 2008); agricultural productivity is low and forest dependence high, i.e. with a significant proportion of households using forests to support their current consumption, e.g. through harvest and use of medicinal plants.

To study variation in forest dependence across indigenous groups and in-migrants, three colonist (Asaí, Aliso Colorado, and Ambaibo; all community names used are fictive to provide anonymity to participating communities) and three indigenous (Bejuco, Blanquillo and Bibosi) communities were included. An overview of the selected communities is presented in Table 1. Community selection criteria were: some degree of forest dependency, low coca production (based on previous field work experience from the area, we judged that high (i.e. illegal) coca production would result in invalid household asset and income data as this is a very sensitive issue), accessibility (that is was likely that communities would grant us permission to conduct research), and proximity (for budgetary reasons communities could not be located too far apart). All six communities are involved in formal forest management and are members of the local forest union (organising communities involved in formal forest management). All six communities have forests that are similar in composition and structure: closed canopy natural high forest characterised by timber species such as mapajo (*Ceiba petambra*), verdolago (*Terminalia* sp.), almendrillo (*Dipterex odorata*), trompillo (*Guarea* sp.), ambaibo (*Cecropia membranacea*), ochoó (*Hura crepitans*), charque (*Eschweilera coriaceae*), coquino (*Pouteria* sp.), jorori (*Swartzia jorori*) and negrillo (*Nectandra* sp.).

Table 1 Overview of six studied communities in the Tropics of Cochabamba, lowland Bolivia, 2006-07 (based on data from the household survey and the forest management plans)

| | **Asaí** | **Aliso Colorado** | **Ambaibo** | **Bejuco** | **Blanquillo** | **Bibosi** |
|---|---|---|---|---|---|---|
| **Yr of establish. / legal land title** | 1984 / 1999 | 1982 / 1999 | 1996 / 2001 | 1970s / 2003 | 1982 / 2000 | Few hh in 1970, more in 2003 / 2006 |
| **Area (ha)[1]** | 1294 | 3346 | 6109 | 428 | 487 | 5159 |
| **No. of hh** | 40 | 119 | 32 | 26 | 24 | 81 |
| **Av. hh size** | 5.4 | 4.8 | 5.6 | 4.7 | 7.5 | 5.8 |
| **No. of sampled hh** | 20 | 37 | 8 | 12 | 12 | 30 |
| **Distance to market (km)** | 35 | 38 | 28 | 20 | 31 | 38 |
| **Accessibility** | Road, taxi service | Road, taxi service | Road being constructed, taxi service and foot | Road, taxi service | Road, taxi service, river | No road, foot and cycle path, river |
| **Main livelihood activities** | Agriculture, timber, hunting, fishing | Agriculture, timber, labour in forest plantations | Own business, agriculture, some fishing | Hunting, fishing, agriculture, small scale livestock | Timber, agriculture, hunting | Hunting, fishing, agriculture, some timber |
| **Forest mgt. plan (ha / yr approved)** | 181 / Oct 2004 | 195 / Nov 2004 | 201 / May 2003 (1400 in prep.) | 123 / Apr 2004 | 156 / Aug 1998 | 2000 / in prep. |
| **Per aeu daily income (USD)[2]** | 2.45 | 2.27 | 1.47 | 1.40 | 1.29 | 1.16 |
| **Notes[3]** | In-migrants | In-migrants | In-migrants | Yuracare | Mojenos, share infrastructure with colonist community | Yuracare, also resides in a peri-urban area |

[1] Total size of community lands, including settlement and communal lands.

[2] Daily income per adult equivalent unit; calculated as per Cavendish (2002); the average exchange rate in the study period was 8.01 Bs/USD in (Bolivian Central Bank 2007).

[3] In-migrants have both private land and communal lands; indigenous groups have communal lands only.

All communities were established fairly recently; all are dependent on agriculture and, for five communities, some degree of hunting and/or fishing. Distances to markets are similar as is accessibility (except for Bibosi that is more isolated). Development of forest management plans were undertaken with the assistance of donor agencies.

## 2. Methods

This section briefly explains how product values were collected. Data collection and handling followed the procedures specified in the PEN prototype questionnaire (2007) and the PEN technical guidelines (2007): first, qualitative rural appraisal at village level was used to generate contextual information about the study area and its people; this information was also used to adopt the prototype questionnaire to the local context. The structured questionnaires were then tested, followed by random selection of households, and application of questionnaires. Appraisal field work started in February 2006 and the last quarterly survey was conducted in January 2007. See Lund et al. (in press) for a discussion of the experiences of using the PEN approach across a range of different sites and conditions.

Before field work could start access to interview households in the six communities had to be negotiated with the association of municipalities as well as the sindicatos and the indigenous councils. Negotiations took three months and resulted in formal written agreements with each community, including agreement on returning preliminary findings to each community in detailed *Carpetas Comunales* (Uberhuaga in press); these serve to share results as well as providing input to any future development and research projects in the communities.

Data collection was undertaken by a small team of research assistants rather than enumerators; the assistants were social science bachelors (economics or sociology) with some research experience and a lot of research interest. The team was trained in the PEN approach to research and data collection. They worked in sub-teams of two people: one asking the questions and the other taking notes and controlling the development of the interview. The questionnaires were pre-tested in a community in the Tropics of Cochabamba by the research team; the experiences gained were used to fine tune approaches to asking sensitive information and to add extra data collection techniques to the rapid appraisals at community-level. Each evening in the field ended with a team meeting where the day's collected data was checked and discussed; inconsistencies and errors were then clarified directly with relevant households the following day.

### 2.1 Rapid appraisal

Contextual information on community history and characteristics were collected using rapid appraisal techniques including communal maps, seasonal activity calendars, resource use flow maps, chronological community history and individual life histories. Communal meetings took three to five hours, mainly in the evening (households are very busy during the day). As the interview team spent between 10 and 15 weeks in each community, it also made participatory observations of households' main livelihood activities (e.g. work in agricultural fields, fishing, wood carving). Direct observations, e.g. of household assets and activities, also formed an important part of the research team members' everyday work; this was used to check the structured survey responses while the interview was going on and probe as required, e.g. to understand in detail the how, when and where of wild fruit collection. Lastly, the research team also recorded long informal conversations with household members.

### 2.2 Household-level structured surveys

Empirical data collection covered the one year period from January 2006 to January 2007. Detailed household-level questionnaires (see PEN prototype questionnaire (2007) and PEN technical guidelines (2007) for further details) were applied at the beginning of the period (focusing mainly on demographics and assets), at the end of the period (focusing mainly on crises in and perceptions of the past year), and quarterly surveys in between (focusing mainly on income). A household in the study area is defined as a "group of people (normally family members) living under the same roof, and pooling resources (income and labour) for their livelihood" (PEN technical guidelines 2007). Most households were made up of family members though occasionally there were households based on ethnic kinship ties. The term community refers to a unit of households with common norms and rights (typically found in scattered villages) under the jurisdiction of a community leader or council.

Up-dated and checked community-level census lists were used to randomly select households for interviews; to enable intra- and inter-community level analyses around 50% of households in each community was initially randomly selected. The initial number of households ($n$ = 165) was substantially reduced over the study period (final $n$ = 118), especially after the first quarterly household-level interview round where an entire community ($n$ = 31) left the study as it found the interviews too time consuming and delving into sensitive issues, e.g. the questions on savings and the detailed recording of income. See Table 1 for an overview of distribution of sampled households across communities. Generally, the quarterly interviews took more than an hour, depending on the interviewer-household relationship – much effort and time was invested in building trust and interviewer-household relationships were very good at the time of the third and fourth quarterly surveys.

### 2.3 Data analysis

Building on the PEN technical guidelines (2007), forest products are defined as products whose supplies depend on the existence of the forest. Forest products are usually collected in forests but mobile products may also be collected outside forests, e.g. an agouti shot in an agricultural field is counted as a forest product as it will not be available if the forest is removed. In the present study, fish are considered non-forest environmental products. Products may be raw or processed. Building on FAO's definition, forests are defined as lands of more than 0.5 ha, with a tree canopy cover of more than 10%, where the trees should be able to reach a minimum height of five meters in situ, and which are not primarily under agricultural land use. Thus, for instance, timber trees grown in agroforestry systems are not counted as forest products but as agricultural products. The data collection instruments were designed to allow distinction between product origins. Forest services are not part of this study.

## 3. Results

In general, the studied households use a large number of forest, non-forest environmental, agricultural and livestock products – we recorded the use of 151 forest and non-forest environmental products. In this paper, for the economically most important products for households, the emphasis is on checking basic distributional statistics for product-level unit values derived from own-reported values. In addition, to increase transparency regarding the valuation techniques, notes are provided on the valuation of economically important forest and non-forest environmental products.

### 3.1 Conversion of local volume units to SI units

Of the 151 forest and non-forest environmental products, used for both subsistence and commercial purposes, 40 products were reported in more than one unit. And more than 50% of all records were made in local units, e.g. *carga* (100 pounds) for coca leaves or *arroba* (11.5 kg) for citrus fruits.

Conversions to SI units were done based on standard tables of weights and units (Jaimes et al. 2001, Mancilla 2003, Rowlet 2005).

### 3.2 Checking own-reported values

During data collection households were asked to estimate the total quantity and value of forest and other products used in a specified period (either one or three months) prior to the quarterly interview; this was then used to value the forest, non-forest, agricultural and livestock products. Cavendish (2002) demonstrated, in Zimbabwe, that such own-reported values for forest and non-forest environmental products can be elicited in the same way as values are elicited for other ‘normal’ economic goods; the household estimates result in aggregate unit values with satisfactory properties. In consequence, estimated values can be used to value resource use in households (in the same season in the same location) that are not able to supply value estimates (or, alternatively, to create a common price for a product in a particular location in a particular period). Whether this approach also yields valid and reliable results when applied in lowland Bolivia is investigated in this section.

Whenever possible own-reported values are based on farm-gate prices; if these are not available, or markets are very thin, barter values (value derived from exchange of product with market commodity), substitute values (value derived from local market price of close substitute), willingness to pay (WTP, group of interviewees agreeing on value of non-traded product) or distant market prices (price on distant market minus transportation costs to market) were estimated. Out of the 151 forest and non-forest environmental products, farm-gate could be recorded for 59 products (39%), and barter/substitute/WTP values for 63 products (42%). The remaining 29 products (19%) were all of marginal importance to local households and were not valued; 25 products (17%) were mentioned just once across all seasons and households and four products (3%) were mentioned a few times by a few households. An overview of basic distributional statistics for unit values of the main ($n \geq 5$) forest, non-forest environmental, agricultural and livestock products are presented in Table 2. The column “Valuation method” specifies how each product was valued. For each product, $n$ is provided for the most disaggregated product (in some cases products were aggregated in the field, e.g. for medicinal plants, and in these cases $n$ refers to the product group where some variation around the mean must be expected).

**Table 2** Unit values (Bs) of main ($n \geq 5$) forest, non-forest environmental, agricultural and livestock products in lowland Bolivia, 2006-07

| Products | Unit of measure | *n* | Mean | s.d. | Median | Min | Max | Valuation method |
|---|---|---|---|---|---|---|---|---|
| **I. Wooden products** | | | | | | | | |
| Almendrillo | $m^3$ | 5 | 654.3 | 233.2 | 635.6 | 420 | 932.2 | farm-gate |
| Frond | Piece | 11 | 7.1 | 8.1 | 3.0 | 1.0 | 25.0 | substitute |
| Fuelwood | Wheelbarrow | 433 | 8.5 | 4.6 | 10.0 | 2.0 | 50.0 | WTP |
| House | Piece | 10 | 4710.0 | 9164.5 | 1500.0 | 300.0 | 30000.0 | substitute |
| Lianas and vines | Piece | 5 | 2.3 | 2.5 | 0.5 | 0.5 | 5.0 | substitute |
| Poles | Poles | 5 | 16.0 | 5.5 | 20.0 | 10.0 | 20.0 | farm-gate |
| Timber | $m^3$ | 44 | 377.4 | 243.5 | 423.7 | 100.0 | 848.0 | farm-gate |
| | Piece | 9 | 370.6 | 378.9 | 200 | 80.0 | 1200.0 | farm-gate |
| Tree leaves | Piece | 5 | 0.7 | 0.4 | 1.0 | 0.0 | 1.0 | WTP |
| Woodcraft | Piece | 5 | 20.0 | 12.8 | 20.0 | 5.0 | 40.0 | farm-gate |
| Wooden furniture | Piece | 9 | 95.2 | 122.5 | 50.0 | 2.0 | 400.0 | WTP |
| **II. Non-wooden products** | | | | | | | | |
| Apple guava | Piece | 5 | 0.4 | 0.4 | 0.2 | 0.05 | 1.0 | substitute |
| Bacuri fruit | Kg | 8 | 4.3 | 2.8 | 4.5 | 1.0 | 10.0 | substitute |
| | Piece | 5 | 0.3 | 0.1 | 0.3 | 0.2 | 0.5 | substitute |
| Cacao fruits | Kg | 8 | 9.5 | 0.9 | 10.0 | 8.0 | 10.0 | farm-gate |
| | Piece | 5 | 0.9 | 0.4 | 1.0 | 0.5 | 1.5 | farm-gate |
| Cat’s claw | Kg | 35 | 12.8 | 6.4 | 12.8 | 2.0 | 30.0 | farm-gate |
| | Litres | 24 | 13.7 | 13.6 | 10.0 | 3.0 | 70.0 | farm-gate |
| | m | 6 | 2.6 | 1.4 | 2.3 | 1.0 | 5.0 | farm-gate |
| | Piece | 14 | 6.4 | 5.8 | 5.0 | 1.0 | 20.0 | farm-gate |
| | Branch | 7 | 1.6 | 1.5 | 1.0 | 1.0 | 5.0 | farm-gate |
| Chirimoya silvestre | Piece | 9 | 1.1 | 0.5 | 1.0 | 0.5 | 2.0 | farm-gate |
| Malva | Leaves | 5 | 0.2 | 0.1 | 0.2 | 0.0 | 0.3 | substitute |
| | Stick | 23 | 0.2 | 0.1 | 0.2 | 0.0 | 0.5 | substitute |
| Medicinal plants | Handful | 8 | 0.8 | 0.1 | 0.8 | 0.8 | 1.0 | substitute |
| | Kg | 8 | 5.5 | 2.8 | 4.0 | 4.0 | 10.0 | substitute |
| | Leaves | 50 | 0.2 | 0.3 | 0.2 | 0.0 | 2.0 | substitute |
| | Piece | 24 | 0.8 | 1.2 | 0.7 | 0.0 | 6.0 | substitute |
| | Stick | 43 | 0.8 | 0.7 | 0.8 | 0.0 | 3.0 | substitute |
| Pacay | Kg | 25 | 2.4 | 1.6 | 1.6 | 0.8 | 5.0 | farm-gate |
| | Piece | 31 | 0.7 | 0.4 | 0.5 | 0.1 | 2.0 | farm-gate |
| Paico | Leaves | 6 | 0.3 | 0.2 | 0.3 | 0.1 | 0.5 | substitute |
| | Stick | 19 | 0.9 | 1.4 | 0.5 | 0.1 | 6.0 | substitute |
| Patauá fruits | Kg | 15 | 6.1 | 4.3 | 5.8 | 0.6 | 15.0 | farm-gate |
| Peach palm fruit | Kg | 30 | 2.3 | 2.3 | 2.0 | 0.4 | 10.0 | farm-gate |
| Thatching grass | Piece | 11 | 2.4 | 2.3 | 1 | 0.3 | 5.0 | substitute |
| Wild fruits | Kg | 20 | 3.6 | 3.1 | 2.2 | 0.4 | 13.0 | WTP |
| | Piece | 19 | 0.9 | 0.8 | 0.8 | 0.0 | 3.5 | WTP |
| **III. Game, fish, insect, honey and guan products** | | | | | | | | |
| Agouti | Kg | 68 | 11.8 | 2.8 | 12.0 | 5.0 | 18.0 | farm-gate |

| Products | Unit of measure | *n* | Mean | s.d. | Median | Min | Max | Valuation method |
|---|---|---|---|---|---|---|---|---|
| Armadillo | Kg | 26 | 7.5 | 2.5 | 6.5 | 5.0 | 12.0 | farm-gate |
| Collared peccary | Kg | 32 | 7.9 | 2.5 | 8.0 | 5.0 | 15.0 | farm-gate |
| Deer | Kg | 12 | 8.6 | 2.8 | 8.0 | 5.0 | 15.0 | farm-gate |
| Fish | Kg | 554 | 9.3 | 3.3 | 10.0 | 2.0 | 25.0 | farm-gate |
| Game meat – birds and bats | Kg | 8 | 9.9 | 3.4 | 10.0 | 5.0 | 14.0 | farm-gate |
| Game meat – mammals | Kg | 12 | 8.8 | 3.7 | 10.0 | 5.0 | 15.0 | farm-gate |
| Guan | Kg | 18 | 9.2 | 5.3 | 10.0 | 5.0 | 25.0 | farm-gate |
| Honey (wild) | Litres | 12 | 15.5 | 7.4 | 12.0 | 8.0 | 35.0 | farm-gate |
| Paca | Kg | 5 | 8.5 | 1.1 | 8.5 | 7.0 | 10.0 | farm-gate |
| Perdiz | Kg | 5 | 9.8 | 4.0 | 10.0 | 5.0 | 15.0 | farm-gate |
| **IV. Agricultural products** | | | | | | | | |
| Achiote | Kg | 25 | 2.9 | 1.1 | 2.8 | 1.2 | 160.0 | distant market |
| Avocado | Piece | 20 | 0.3 | 0.1 | 0.3 | 0.1 | 0.5 | farm-gate |
| Banana | Bunch | 16 | 6.6 | 2.5 | 5.5 | 4.0 | 11.0 | farm-gate |
| Plantain (banana – cooking) | Bunch | 318 | 4.7 | 1.3 | 5.0 | 1.5 | 10.0 | farm-gate |
| Plantain (guineo) | Bunch | 14 | 4.9 | 1.6 | 5.0 | 3.0 | 7.0 | farm-gate |
| Beans | Kg | 7 | 2.2 | 1.0 | 2.0 | 1.3 | 4.0 | farm-gate |
| Cassava/manioc (fresh) | Kg | 218 | 0.5 | 0.4 | 0.4 | 0.1 | 4.0 | farm-gate |
| Coca leaves | Pound (lb) | 302 | 10.9 | 2.0 | 10.0 | 4.0 | 20.0 | farm-gate |
| Cucumber | Kg | 5 | 0.9 | 0.6 | 1.0 | 0.3 | 1.7 | farm-gate |
| Grapefruit | Piece | 6 | 0.3 | 0.3 | 0.2 | 0.1 | 0.8 | farm-gate |
| Palm heart | Piece | 5 | 1.2 | 0.1 | 1.2 | 1.0 | 1.3 | farm-gate |
| Hojas de achiote | Kg | 5 | 1.0 | 0.0 | 1.0 | 1.0 | 1.0 | distant market |
| Lemon | Piece | 9 | 0.3 | 0.3 | 0.2 | 0.1 | 1.0 | farm-gate |
| Lime | Piece | 5 | 0.1 | 0.1 | 0.1 | 0.0 | 0.2 | farm-gate |
| Maize | Kg | 54 | 0.9 | 0.5 | 0.8 | 0.2 | 2.5 | farm-gate |
| Orange | Piece | 76 | 0.1 | 0.0 | 0.1 | 0.0 | 0.3 | farm-gate |
| Pacay (cultivated) | Piece | 6 | 0.5 | 0.3 | 0.5 | 0.2 | 1.0 | farm-gate |
| Pineapple | Piece | 10 | 0.9 | 0.3 | 1.0 | 0.5 | 1.5 | farm-gate |
| Potato | Kg | 6 | 1.3 | 0.9 | 1.0 | 0.6 | 3.0 | barter |
| Papaya | Piece | 58 | 0.8 | 0.5 | 0.6 | 0.3 | 4.0 | farm-gate |
| Rice | Kg | 109 | 1.5 | 0.7 | 1.4 | 0.3 | 3.2 | farm-gate |
| Tangerines | Piece | 19 | 0.1 | 0.1 | 0.1 | 0.0 | 0.5 | farm-gate |
| Tomato | Kg | 8 | 1.6 | 1.0 | 1.5 | 0.5 | 3.0 | farm-gate |
| Walusa | Kg | 11 | 0.4 | 0.1 | 0.4 | 0.3 | 0.5 | farm-gate |
| **V. Livestock products** | | | | | | | | |
| Cattle | Piece | 58 | 1415.0 | 461.5 | 1328.5 | 500.0 | 2800.0 | farm-gate |
| Chicken | Piece | 377 | 22.5 | 3.8 | 25.0 | 1.0 | 35.0 | farm-gate |
| Ducks | Piece | 57 | 27.8 | 7.1 | 30.0 | 10.0 | 45.0 | farm-gate |

| Products | Unit of measure | *n* | Mean | s.d. | Median | Min | Max | Valuation method |
|---|---|---|---|---|---|---|---|---|
| Eggs | Piece | 268 | 0.5 | 0.1 | 0.5 | 0.2 | 1.0 | farm-gate |
| Goats | Piece | 8 | 58.8 | 23.0 | 60.0 | 30.0 | 80.0 | farm-gate |
| Honey (cultivated) | Kg | 13 | 10.7 | 1.3 | 10.5 | 8.5 | 14.0 | distant market |
| | Litres | 9 | 8.9 | 2.3 | 9.0 | 4.0 | 12.0 | distant market |
| Milk | Litres | 21 | 1.9 | 0.4 | 2.0 | 1.0 | 2.5 | farm-gate |
| Pigs | Piece | 82 | 274.0 | 177.8 | 200.0 | 70.0 | 800.0 | farm-gate |
| Rabbit | Piece | 15 | 14.8 | 6.7 | 12.0 | 5.0 | 30.0 | farm-gate |
| Sheep | Piece | 16 | 77.5 | 37.7 | 80.0 | 30.0 | 170.0 | farm-gate |

Table 2 shows that the households' own-reported values can be used as a measure of product values – the estimates result in aggregate unit values with satisfactory properties: the standard deviation is much smaller than the mean and the median and modal values are similar and close to the mean. In addition, for products that were reported in more than one unit, the ratio of unit values are similar to the ratio of quantities as we would expect, e.g. one bacuri fruit is valued at 0.3±0.1 Bs while one kg is valued at 4.3±2.8 Bs; from household interviews we know that one kg is made up of around 15 fruits so the kg price derived from the per fruit price is around 4.5 Bs. In Table 2, we would also expect to find that the value of processed products is higher than for the same unprocessed products (e.g. wood vs. processed wood in the form of woodcraft and wooden furniture); however, the local units reported and the lack of accurate quality and volume assessments at product level (e.g. how much wood of what species is used to produce what furniture) does not allow for such comparisons.

There are exceptions to the above patterns, especially for the wooden products, e.g. pieces of timber or wooden furniture. This is due to large differences in quantity (large and small pieces) and quality (use of different species). These differences also explain dispersion in the unit values of key products such as fuelwood; for this and other products some dispersion is also explained by spatial variability, e.g. in fuelwood availability.

In the following, in order to increase transparency regarding the valuation techniques, notes are provided on the valuation of the forest and non-forest environmental products**.**

*Generally important traded forest and non-forest environmental products*

Households usually perceive **timber** as the most valuable forest and environmental product; it is used for construction of houses, furniture and utensils and many species can be sold; farm-gate prices are generally well-known especially due to the communities' involvement in formal forest management plans. It was not difficult to value non-traded used species. Reported values were provided in *pie tablar* (pt) and converted to m³ (1 pt = 0.00236 m³). Another important forest product is the seasonal **peach palm fruit** (*Bactris gasipaes*) harvested mainly from January to April; it is consumed locally in many forms (fruit, powder, alcoholic beverage) and traded; the value is 2.36±2.31 Bs/kg (*n* = 29). Another important seasonal fruit product is **patauá fruits** (*Oenocarpus bataua*), a source of calcium, proteins, minerals and an olive-like oil, valued at 6.1±4.3 Bs/kg (*n* = 15). Wild collected **honey** is found in small quantities only and used for subsistence consumption while honey from beekeeping (maintenance of honey bee colonies, typically in hives, by households) is sold to an association of producers; both products were easily valuated at 15.5±7.4 Bs/l (*n* = 12) and 8.9±2.3 Bs/l (*n* = 9) respectively. **Cat's claw** (*Uncaria guianensis*) is the most important medicinal plant; it is consumed in households and sold; nine units of measurements for cat's claw were recorded; it was valued at 12.8±6.4 Bs/kg (*n* = 35). The most important **fish** species are sabalo (*Prochilodus nigricans)* and pacu (*Colossoma brachypomum*); again, these are both consumed locally as well as traded and were valued using farm-gate prices; a few households specialise in commercial fishing of these species. We recorded use of another 25 fish species in the study area (all just coded as fish along with sabalo and pacu in the data base); they are usually harvested in small amounts for immediate cooking (breakfast or dinner). These were valued based on comparison with sabalo and pacu; all unit values were lower for these 25 species. The average value for all fish species is 9.3±3.3 Bs/kg (*n* = 554). Fruits (and seeds) of **cacao** (*Theobroma cacao*) are collected in the forests in the dry season (May to September); seeds are either sold or dried for preparation of traditional chocolate. Not many families work with this product as it is not common; however, prices were well-known (9.5±0.9 Bs/kg, *n* = 8).

*Generally important but non-traded forest and non-forest environmental products*

The single most important source of energy, used by all households, is **fuelwood** – this product is abundant, large forest areas are very close to all communities and households, and not traded. Few households in the study area use substitutes. The most common fuelwood unit was the wheelbarrow (also common was the *cocinada*: the daily amount required for cooking) which is commonly used for fuelwood transportation from forest-to-house; the average value was estimated at 8.5±4.6 Bs/wheelbarrow (*n* = 433).

Value dispersion reflects spatial variability (across communities and households) due to differences in availability (e.g. in three of the communities cut trees were available in abundance due to recent clearance of forest for agricultural fields) and quality (species composition and moisture content). Regarding **medicinal plants**, we noted the use of 50 species and nine units of measurement; only cat's claw (see above) is traded. The rest are reported to be abundant, in low demand and solely used for self-consumption. Most medicinal plant products are harvested in the forest (leaves 28%, branches 39%, seeds or fruits 28% and resins/oils 5%), but home gardens and fallows are also important supply sources. Deriving substitute prices from locally available allopathic medicine treating similar conditions was not done due to questions of differences in efficacy. Instead we asked households to provide a subjective valuation by (i) comparing to cat's claw – used for species used to treat the same conditions, such as stomach problems and children diarrhoea, as cat's claw; this included the species asai (*Euterpe precatoria),* raiz amarga (*Gentiana asclepiadea*) and retoño de guayaba (sprout of apple guava – *Psidium guajava*); as expected such valuations always resulted in lower values than for cat's claw; (ii) asking how they would barter a specified medicinal plant product amount with four breads (valued at Bs 1) or one egg (valued at Bs 0.5). For the most common medicinal plants, such as paico (*Chenopodium ambrosioides*), we got a value of 1.0±1.4 Bs per unit (such as one piece used to prepare an application, e.g. paico tea), while less common species were valued around 0.2±0.1 Bs per unit.

*Occasionally important, occasionally traded forest and non-forest environmental products*

This group of products is usually used for subsistence purposes only; households prefer alternatives but they remain seasonally important and serve safety net functions in times of hardship – when local markets are also established for these products. Prices thus vary among years and seasons. The observed year was a normal year, compared with the last five years, except that all communities were affected by floods leading to some crop losses in the last quarter of 2006.

Valuation of **wild fruits** (pacay, maracuya, ocoro, carambola, chirimoya silvestre) was done by households for the most common products, including pacay (*Inga sp.*; 2.4±1.6 Bs/kg, $n = 22$) and chirimoya silvestre (*Rollinia edulis*; 1.1±0.5 Bs/piece, $n = 7$). For these products, with an occasional market, farm-gate prices could be obtained. For other products, values were obtained through discussions where villagers identified substitute values or their willingness to pay for a particular product; values, usually per piece of fruit or per kg, were typically identified from comparison with traded fruits or agricultural products with known values. The non-traded wild fruits were valued lower than traded wild fruits, such as patauá fruits mentioned above; e.g. bacuri fruit (*Garcinia* spp.) was valued at 0.3±0.1 Bs/piece ($n$ = 5) and apple guava (*Psidium guajava*) at 0.4±0.4 Bs/piece ($n$ = 5). Less common wild fruits were assigned one common value (3.2±2.9 Bs/kg, $n$ = 24). **Thatching grass** is used to make roofs; many different species are used including palm, chuchio and palla leaves. Households found valuation difficult (2.4±2.3 Bs/piece, $n$ = 11) and future valuation efforts would benefit from distinguishing thatching grass products as quality varies significantly. The same is probably true for **lianas and vines** (2.3±2.5 Bs/piece (usually 2m), $n$ = 5) used for binding. Regarding **game meat**, households found it easy to value meat that was frequently hunted and occasionally traded such as agouti (11.8±2.8 Bs/kg, $n$ = 68), collared peccary (7.9±2.5 Bs/kg, $n$ = 32) and armadillo (7.5±2.5 Bs/kg, $n$ = 26). However, other less frequently hunted and traded species, such as parrots, monkeys and white-lipped peccary, were more difficult to value. These were eventually valued using farm-gate prices, obtained through interviews with hunters in an indigenous neighbouring village, located three km down the river, who were locally known to regularly provide local markets with game meats. Trade in illegal products, such as skins and live animals, were not observed or recorded.

## 4. Discussion and conclusion

Households in the study area used a huge array of forest, non-forest environmental, agricultural and livestock products that are both traded and consumed locally; valuing all these products is time consuming but possible using the households' own-reported values. Even for non-traded products useful estimates can be collected. The resultant aggregated unit values generally have satisfactory properties. For key products, those that are commonly used by households, the quality of own-reported data can be increased by (i) explicitly specifying product quality differences, e.g. by attempting to distinguish main types of fuelwood – the better defined a product is the less variation in value estimates due to not recorded quality differences, and (ii) collecting information on local volume units at product level; this would allow more thorough cross-check of the ratio of reported unit values to the ratio of quantities.

When using own-reported values in income calculations, it could be argued that it would be most appropriate to use aggregated average product prices, rather than the individual household-level recorded values, in order to avoid household-level preferences influencing income estimates. However, this paper indicates that such an approach should not be used as, as also noted by Cavendish (2002), the household-level values are likely to be more accurate: (i) units of measurements are not identical, e.g. a collared peccary or a wheelbarrow of fuelwood may be either small or large, (ii) there are large not recorded product differences, e.g. the wheelbarrow of fuelwood can also vary in species composition and moisture content, and (iii) there is spatial variability in values, e.g. fuelwood may require less labour to collect in some villages.

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# The legendary journey of three valiant english forest economists from Flåm to Lom and a celebration of the papers that they missed

Colin Price

They told Newcastle[43]'s travel bureau
that this meeting was in Lom[44].
And left that port where many Euro-
peans travel eastwards from.
And, whether they pronounced it badly,
or the agent had misheard,
he routed them to Flåm, which, sadly,
isn't near …. Still, undeterred,
they chose to walk, despite unpleasant
weather. Though delayed, at least
they hoped that they would all be present
at the conference's feast.
In snowfall fit for neither man nor beast
they set a compass course north-east.

They should have made their start from Otta,
if they sought a pleasant stroll[45].
Yet all Englishmen have got a
rod of steel in their soul;
plus this pig-headed disposition:
to turn back is to be disgraced –
the stupider the expedition,
the firmer it should be embraced!
They travelled light, with scant provisions
on the side of *Sognefjorden*,
knowing in today's decisions
past mistakes should be ignored – un-
less past costs will be restored an-
other day, across the board.

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[43] Natives of Tyneside put emphasis as in New**CAS**tle.
[44] In this part of Ottadalen, they *did* seem to pronounce it to rhyme with "from".
[45] It's only 60 km to walk from Otta, mostly on nice, snow-free forest tracks.

But what they missed! It would have been a
treat our PowerPoints to see!
with papers drawn from each arena
known to *skogøkonomi*:
computer programs to promote a
protocol that would enhance
bird habitats in Minnesota,
carbon stocks in south-west France;
young researchers who express ass-
urance, that demands exist
for aged wood decks (while aged professors
drank their beer, and reminisced.
And drank more beer, and got … a list
of other beers they might have missed.)

So, while they walked, our gallant trekkers
missed the Danes'strategic games,
talks on harvest costs, and Pekka's
piece on wood construction frames;
Christmas trees and pure ground water;
selling wood to architects;
things that make rotations shorter –
tree stems longer; tax effects.
And any paper lacking mention –
trees' control on global climate,
firewood, forestry extension –
was cut out by need to rhyme it,
make it metric, or the time it
takes to read prose so sublime.

On, north-east, our valiant heroes
painful progress slowly made,
confronting two life-threat'ning zeroes: –
zero sense, and zero centigrade;
grimly grabbing Norway spruces'
branches with each footing missed –
one of cellulose's uses
for which markets don't exist.
(And *that* is one of many diverse topics
that in future you must underscore: you'll
need examples from the tropics,
temp'rate regions, and the boreal.
Any international tutorial
must mean teaching more than immemorial
facts that students used to learn before!)

Onwards still across the *jøkulls*,
up the *fjells* and down the *dals*,
shouting English at the locals
in a landscape like Nepal's;
on, with energy fantastic,
never stopping for a break,
up and down – just like stochastic
walks that market prices take.
So, having talked of fluctuating
rates at which the market lends,
let's now join in celebrating
these, and other, absent friends,
who made mistakes, and could not make amends,
or else were left too poor to come at all, by long-term timber prices' trends.

And there were presentation slots relating
how folk, frozen out by winds of change,
risk exclusion from participating:
meanwhile, high upon the mountain range,
risking being cold cadavers
frozen by the bitter wind,
on, our English heroes traverse
Galdhøpiggen, Glittertind.
But now I must report with deepest sorrow,
the fate that soon awaits these coolest dudes:
they should arrive at Fossheim[46] late tomorrow,
exactly as our conference concludes.

[46] Note for non-participants: the conference was held at the Fossheim Turisthotell, Lom.

# List of participants

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# Program

| DAY | HOUR | | |
|---|---|---|---|
| Sun 6th | 20:00 | Registration and welcome drink at the hotel | |
| Mon 7th | 08:30 | **Opening of the meeting**<br>**Key note** Stephanie Snyder (senior researcher USDA Forest Service Northern Research Station St. Paul):<br>"Application of optimization decision models to habitat reserve selection and open space land acquisition | |
| | 10:00 | **Coffee break** | |
| | 10:30 | **Business Economics of Forestry & Forest Management and Planning**<br>*Moderator: Harri Hänninen* | **Forest Industry & Forest Products Markets**<br>*Moderator: Anders Q. Nyrud* |
| | 10:30 | # Cost-benefit analysis of continuous cover forestry - Colin Price | # Strategic transformation to customer-orietention in the Swedish sawmilling sector - Denise McCluskey |
| | 11:00 | # Optimal rotation of pine stand under different stochastic price models - Saeed Bayazidi | # Marketing of wood in construction to architects and designers – a study on attitudes and perceptions - Anders Roos |
| | 11:30 | # Implications of extreme and mean ratio in near-natural forest management planning - Peter Tarp | # Consumer preferences for wood surfaces - a latent variable approach - Jon Bingen Sande |
| | 12:00 | **LUNCH** | |
| | 13:00 | **Sessions cont.**<br>*Moderator: Cristoph Hartebrodt* | **Sessions cont.**<br>*Moderator: Anders Roos* |
| | 13:00 | # Using lumber grade and by-products' yield predictions for standing Scots Pine trees in stand level optimization - Henna Lyhykäinen | # Costumer satisfaction: an empirical example with wooden decking materials - Anders Q. Nyrud |
| | 13:30 | # PRAP to enhance local organizational capacity - Alvaro Rico | # International market establishment among small and medium sized Swedish furniture producers. - Åsa Devine |
| | 14:00 | | # Cross-sectoral innovation policy challenges in wood frame construction - Pekka Ollonqvist |
| | 14:30 | **Coffe/fruit** | |
| | 15:00 | **Sessions cont.**<br>*Moderator: Peter Tarp* | **Sessions cont.**<br>*Moderator: Sjur Baardsen* |

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|---|---|---|---|---|
| | 15:00 | # Determinants of the price of hunting contracts - Thomas Lundhede | # Econometric analysis of wood supply in ten European countries - Hanne Sjølie | |
| | 15:30 | # What Makes Reporting Successful? A First Approach with a Bayesian Belief Network - Christoph Hartebrodt | # Economic effects of russian customs programme for roundwood exports on eastern Finland and the Republic of Karelia - Ilkka Pirhonen | |
| | 16:00 | # Optimal rotation under continually or continuously declining discount rate - Colin Price | # Sustainability, profitability and shareholder value in forest industries - Olli Saastamoinen | |
| | 17:00 | **Information meeting on travel bills** | | |
| | 19:00 | **Dinner** | | |
| Tue 8th | 08:30 | **International Forestry**<br>*Moderator: Olli Saastamoinen* | **Forest Policy**<br>*Moderator: Bo Jellesmark Thorsen* | |
| | 08:30 | # Forest Income and economic dependency on forest resources in the Bolivian Lowlands - Patricia Uberhuaga | # Conflicts between drinking water protection and income from Christmas tree production - Henrik Meilby | |
| | 09:00 | # Illegal wood harvesting as predation - Ole Hofstad | # Multiple motives of family forest owners in spontaneous speech about decision making - Teppo Hujala | |
| | 09:30 | # Who benefits or loses from Joint Forest Management? Lessons from Andhra Pradesh, India - Moeko Saito-Jensen | # Contract design from a landowner perspective - Stine Wamberg Broch | |
| | 10:00 | **Coffee break** | | |
| | 10:00 | **International Forestry**<br>*Moderator: Ole Hofstad* | **cont.**<br>*Moderator: Teppo Hujala* | **Forest Industry & Forest Products Markets**<br>*Moderator: Heikke Pajuoja* |
| | 10:00 | # Households economic dependence on the forests in rural Nepal - Santosh Rayamajhi | # Risk perceptions and timber harvest decisions - an empirical study of NIPF owners in Northern Sweden - Mats Andersson | # Development of management and cost accounting of wood harvesting in the Republic of Karelia - Olga Tyukina |
| | 10:30 | # The implications of EU's renewable energy policy for the wood use in Europe and especially in Finland and Sweden - Jarmo Hämäläinen | # Family forest owners' retention tree management behaviour - Harri Hänninen | # Impact of thinning intensity on the harvesting costs of first-thinning wood in Scots Pine stands - Kalle Kärhä |
| | 11:00 | # Assessing effects of participatory forest management on forest conservation: A case of village managed miombo woodland forest in Iringa, Tanzania - Henrik Meilby | # Effects of cost sharing in forest management in Norway - Even Bergseng | # Kemera supports and the profitability of small-diameter energy wood harvesting from young stands in Finland - Aaron Petty |

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| | 11:30 | # Using payments for environmental services to secure livelihoods and environmental services in coffee agroforests - Aske Skovmand Bosselmann | # Fragmentation development of the family forestry in Finland - Jussi Leppänen | |
| | 12:00 | **LUNCH** | | |
| | 13:00 | **Key note:** Audun Rosland (senior advicer in the climate section of the Norwegian Pollution Control Authority)<br>"UNFCCC Forest negotiations in Bali 2007 - what happened, what were agreed upon, and how to follow up the agreements?" | | |
| | 14:30 | **Coffee/snacks** | | |
| | 15:00 | **Forest Policy**<br>*Moderator: Anne Stenger* | **cont.**<br>*Moderator: Carsten Smith Olsen* | **cont.**<br>*Moderator: Pekka Ollonqvist* |
| | 15:00 | # Short inquiry into income effects in WTP studies - Jette Bredahl Jacobsen | # The social costs of carbon sequestration in forestry; the example of the southwestern french forest - Guillaume Pajot | # Why harwarders for wood harvesting? - Kalle Kärhä |
| | 15:30 | # Transferring non-timber benefits across time and space: Experiences to date, future, potential. - Anna Bartczak | # Carbon Reservoirs in Wood Products-in-use in Finland: Current Sinks and Scenarios until 2050 - Jani Laturi | # Competitiveness of whole-tree bundling in early thinnings - Heikki Pajuoja |
| | 16:00 | # First-movers, non-movers and subsidies in emerging markets for recreational goods - Bo Jellesmark Thorsen | # Further thoughts on certification and markets - Colin Price | |
| | 16:45 | **Information meeting about glacier tour (Thursday's optional excursion)** | | |
| | 19:00 | **50th Anniversary dinner of SSFE! Takes place at Vianvang** | | |
| Wed 9th | 09:00 | **Business meeting of the SSFE** | | |
| | 11:00 | **Lunch** | | |
| | 12:00 | **Excursion: Nature based tourism or early departure (see seperate program for details)** | | |
| | 16:00 | Return from excursion | | |
| | (17:00 | departure) | | |
| | 19:00 | **Dinner** | | |
| Thu 10th | 08:00 | Departure for Gardermoen airport / optional excursion | | |
| | 17:00 | Departure | | |