Small-scale forestry in Sweden

- owners' objectives, silvicultural practices and management plans

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Abstract

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The purpose of the thesis was to improve the tools for decision making for small-scale forest owners in Sweden. Understanding the objectives of forest owners is crucial for the success of policy initiatives and for promoting successful sustainable forest management. The aims of this thesis were to: a) depict the green forest management plan from a nature conservation point of view; b) identify objectives of owners'; c) analyse different types of owners; and d) evaluate the suitability of silvicultural practices for fulfilling multiple objectives.

The link between the policies at different levels – the inventory instruction – the counselling – the management plan and the forest owners was studied. Discriminant analysis was used to study the professional foresters' choice of areas set aside for nature conservation. A theoretical model for empirical studies of objectives was constructed. Explorative qualitative interviews with foresters and forest owners were conducted, followed by a quantitative study using cluster analysis to identify different types of forest owners. A literature review was undertaken to study silvicultural practices, followed by an analysis of the relationships with the objectives. In addition, a method for evaluating results of research within the field was presented.

The results showed that the contact between professional foresters and the forest owner is a weak point during the production of the plan. Economic consideration was not the major consideration for the planners in the selection of nature conservation compartments in the Green forest management plan. The objectives and motivations of small-scale forest owners of today covered a broad field from nature conservation to tax planning. The four motivations depicted during the interviews were 'conservation', 'utilities', 'amenities' and 'economic efficiency'. The following sub-groups of forest owners were differentiated from the quantitative data: 'the economist', 'the conservationist', 'the traditionalist', 'the optimist' and finally 'the pessimist'. The results also indicated that thinning, different forms of natural regeneration and cleaning are useful practices, whereas 'passive practices' seem to be unsuitable for multipurpose objectives.

Although the results show that forest owners can be differentiated by their objectives, more importantly the results show that precise individual silvicultural programmes can be created for each owner.

Key words: farm forest, forest owners goals, forest values, multiple objectives, NIPF owners, privately owned forest, qualitative methodology, quantitative methodology, smallholder forestry.

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Appendix

Papers I-IV

The present thesis is based on the following papers referred to by their Roman numerals:

I. Ingemarson, F., Dahlin, B. & Hedman, L. 2004. Nature conservation in forest management plans for small-scale forestry in Sweden. *Small-scale forest economics, management and policy* 3 (1), 17-34.

II. Hugosson, M. & Ingemarson, F. 2004. Objectives and Motivations of Small-scale Forest owners'; Theoretical Modelling and Qualitative Assessment. *Silva Fennica* 38 (2), 217-231.

III. Ingemarson, F., Lindhagen, A. & Eriksson L. 2004. A typology of small-scale private forest owners in Sweden. Manuscript.

IV. Hörnfeldt, R. & Ingemarson, F. 2004. Evaluation of silvicultural practices from a multipurpose perspective. Submitted.

Introduction

Policy instruments

The purpose of the thesis was to improve the tools for decision making for small-scale forest owners. Understanding the objectives of forest owners is important for the success of policy initiatives, for promoting successful sustainable forest management (Bliss & Martin 1990) and for adapting extension services to the varying motivations of the forest owners (Kurtz & Lewis 1981, Karppinen 1998a). Societal instruments that influence the structure of the forest owners include: agricultural and forest policy; the land reform law; the land acquisition law; subsidies; and finally the Forestry Act (Eriksson 1989a). Policy instruments, for example forest management plans, have to be consistent with the underlying values of the small scale forest owners', sometimes referred to as non-industrial, smallholder or family forests owners' (Harrison *et al.* 2002), to have an influence on their management activities (Ingemarson *et al.* 2004). The production of timber sometimes has little, even negligible, significance for the economy of the owners' households. Despite this, the forest can still be of great strategic significance for the owners' way of life. Thus, the perspectives of researchers and policymakers concerned with issues related to forest owners must broaden in order to consider aspects of forest owners attitudes and behaviour beyond their role as suppliers of timber (Törnqvist 1995). Bengston & Xu (1997) point out that forest values cannot be reduced to a single dimension, as the values are multidimensional and Karppinen (1998a) suggests that a sole emphasis on economic benefits does not lead to active silvicultural and harvesting behaviour.

The forest management plan is an important tool for decision making within small scale-forestry. Studies of the internalised driving forces of people can be utilised for increasing awareness of the different types of values and ideas in relation to forest management and to enhance the opportunities to manifest personal ideas in the construction of forest management plans and silvicultural systems. This study examined various kinds of forest owners, which should interest not only the forest industry, but also for example environmental non-governmental organisations and estate agents. The study was intended to provide a tool for forest owners and professional foresters to implement the objectives of the owners' into forest management planning.

Changing attitudes

Ideas regarding proper forest management appear to change in conjunction with value-changes in society (Hugosson & Ingemarson 2004). Economic development appears to render material objectives less preferable and are gradually replaced by objectives concerning quality of life. Several studies indicate that a change in human values has taken place (Harding *et al.* 1986, van Raaij 1993, Hakelius 1996, Bengston & Xu, 1997). In Sweden, changes in legislation during the early 1990s (in the land reform law and the land acquisition law) resulted in deregulation of the property market. The farmer's pre-emptive rights were largely terminated, which

allowed a new generation of small-scale forest owners with a different set of values to enter the property market (Hugosson & Ingemarson 2004). The forest owners' rights and obligations during forest management are regulated by the Swedish Forestry Act. A change in human values was politically manifested when the new Forestry Act passed by the Swedish parliament and came into force in 1994. In the first paragraph it states (National Board of Forestry 1994, p.8): "The forest is a National resource. It shall be managed in such a way as to provide a valuable yield and at the same time preserve biodiversity. Forest management shall also take into account other public interests." At the same time, some provisions of the Act are less detailed than corresponding provisions in the preceding legislation, leaving decisions largely to the forest owner. In the former Act a forest management plan was required, whereas in the 1994 Forestry Act only a description of the forest is required. In order to construct a management plan according to the wishes of the forest owner, data on how owners intend to manage their forest is required *i.e.* to try to develop the current management plan that parallels traditional aspects and ideas corresponding to the old legislation.

Forty percent of the private forest acreage has more than one owner. With about 350 000 owners and an average acreage of about 45 hectares productive forest, private holdings encompass approximately 50 percent of the total area of productive forest in the country, or 11.4 million hectares (National Board of Forestry 2003). In the South, properties are smaller, with greater productivity compared to those in the north of the country. Most small-scale forest owners live in the South and control 57% of the timber production in the country (Törnqvist 1995). Approximately one-quarter of forest owners earn at least part of their living through forest-related activities (Lidestav & Nordfjell 2002) and the most commonly used silvicultural practices are clear cutting, followed by planting, cleaning and thinning (National Board of Forestry 2003). The small-scale owners are not only concerned with wood production and profit, but with, *e.g.* conservation and amenities (Hugosson & Ingemarson 2004). In Sweden, the trends indicate that: increasing proportions of small-scale forest owners are living outside their property (Lidestav & Nordfjell 2002); the number of owners that are farmers is decreasing (Eriksson 1989a, Törnqvist 1995, National Board of Forestry 2003); larger proportions of forest properties are being shared by groups of owners (Lidestav & Nordfjell 2002, Mattson *et al.* 2004); and the proportion of female owners is increasing (Lidestav & Ekström 2000).

In Sweden during recent decades, several studies have examined various issues related to small-scale forest owners. These include:

- the differentiation of the forest owners (Eriksson 1989a, b, Löfgren 1989a, b, c, Lönnstedt 1989, Wallner 1989, Carlén 1990, Sennblad 1990, Dahlin & Eriksson 1992, Törnqvist 1995, Lidestav & Ekström 2000, Hugosson & Ingemarson 2003, 2004, Mattsson *et al.* 2004)
- harvesting behaviour (Drakenberg & Höök 1975, Drakenberg *et al.* 1978, Carlén 1986, Carlén & Löfgren 1986, Lönnstedt 1986, Sennblad 1988a, b, 1996)
- decision models (Hansson *et al.* 1990, Lönnstedt & Törnqvist 1990, Lönnstedt 1997)

· subsidies (Forestry Board Organisation 1986, Hultkrantz 1986, Swedish National Audit Office 1986)
· information and counselling (Roos & Törnqvist 1991, Eliasson 1993, Westergren 1994, Sennblad 1998, Ingemarson & Hedman 2001, Ingemarson *et al.* 2004)
· taxes (Löfgren 1992, Håkansson 2002).

Outside Sweden, the following studies of forest owner's objectives are among the most important: for Denmark, Boon *et al.* (2004); for Finland, Pietarinen (1987), Kuuluvainen *et al.* (1996), Ripatti & Järveläinen (1997), and Karppinen (1998b and 2000); and for the US, Kurtz & Lewis (1981), Marty *et al.* (1988), and Bliss & Martin (1989).

Sweden - a diversified country

The population in Sweden is about nine million and the area similar to Spain or California (450,000 km², corresponding to174, 000 sq. miles). Sweden is characterised by its long coastlines, large forests and numerous lakes (Figure 1).

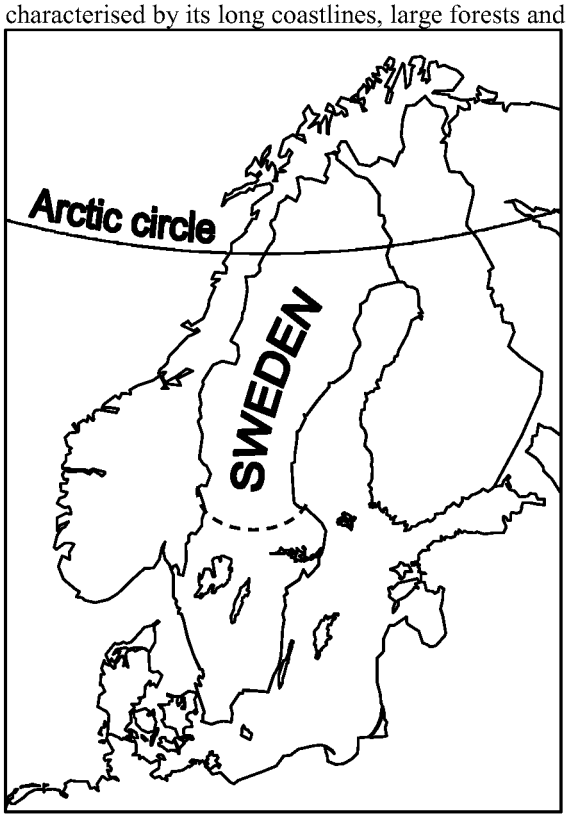


Figure 1. Map of Scandinavia with the north-south delineation (--) indicated.

The landscape is dominated by coniferous forests (*Picea abies* and *Pinus sylvestris*), and in the South often mixed with deciduous trees, such as aspen (*Populus tremula*) and birch (*Betula pubescens* and *Betula pendula*). Other hardwoods such as oak (*Quercus robur*), beech (*Fagus sylvatica*), linden (*Tilia cordata*), maple (*Acer platanoides*) and elm (*Ulmus glabra*) are found up to the border of Norrland (*Limes Norrlandicus*). North of this delineation, the landscape consists of large forests and river valleys, hills and mountains. The southern part has a varied terrain of fields, hills and lakes. The country is famous for its long light summer days and dark winter nights, especially in the North were the winter is long and cold.

Sweden has large numbers of moose (*Alces alces*), roe deer (*Capreolus Capreolus*), foxes (*Vulpes vulpes*) and hares (*Lepus timidus and Lepus eurapeus*). Moose hunting is not only important from an economic point of view, but also

from a cultural point of view. Hunting is closely regulated and most species are fully protected. The numbers of wolves (*Canis lupus lupos*), bears (*Ursus arctos*) and lynx (*Felis lynx*) are increasing. In 1910, Sweden was the first European country to establish national parks to protect sensitive natural scenery and cultural heritage. In Sweden, everyone is entitled to hike through forests and fields picking mushrooms and berries, under the customary right of common access ('Allemansrätten').

Swedish forestry has a long tradition and thereby provides useful cases for empirical studies. The forest industry has been of great importance for both Swedish economy and employment. Formerly, firewood, charcoal and tar were extracted, whereas today the majority of raw material is used for pulpwood, sawn wood or fuel wood. The increase in prosperity during the last centuries depended upon the forestry and the structure of the forest owner. A large number of small-scale private forest owners enabled an increase in prosperity in the whole society. Forests in Sweden are usually divided into four groups according to the status of the owners (Figure 2): private forests, company forests, state-owned forests and community forests. Company forests dominate in the North, whereas in the South private forests dominate.

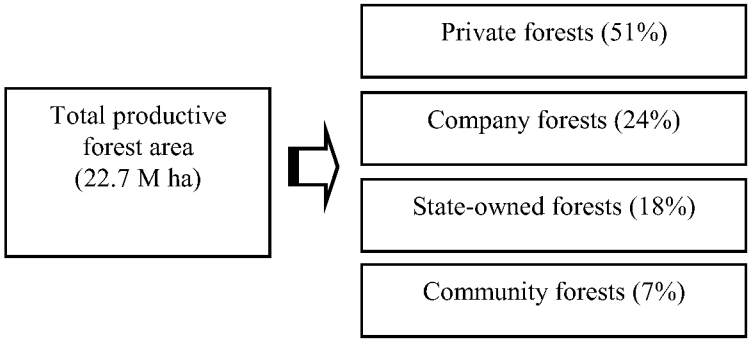


Figure 2. The distribution of forest area according to the status of the owners (National Board of Forestry 2004).

Green forest management plans

During the 1980's, discussion about forestry as a major cause for the depletion of the biological diversity intensified (World Commission on Environment and Development 1987). In Sweden, this influenced the attitudes of both forest companies and the public. Most forest companies and forest owner associations started to investigate how to handle this issue and several projects were initiated in which expertise on forest management and biological diversity was applied in an effort to combine the different goals (Rülcker *et al.* 1994, Dahlin & Sallnäs 1994). As the new Forestry Act was passed in 1994, the National Board of Forestry began development work with 'Green' forest management plans. Simultaneously, other organisations worked with corresponding plans. The Board wished to express a new approach, and today, nature conservation is an important part of the political agenda.

The goal of a 'Green' management plan is to give a comprehensive picture of production and environmental conditions of the property and to provide management proposals that result in sustainable forestry. Forest management plans in Sweden are mostly produced by agencies. A commission to produce a plan for the small-scale forest owners' provides an opportunity for different organisations and society to implement forest policies intentions in the management proposals. The consequence has been that the forest owners objectives have fallen into the background. Contracted by the forest owner, the organisation produces the plan, provides information and consultation. Briefly, a plan is developed first by identifying and delineating compartments on a map with the help of aerial photographs and field control. For each compartment, averages for the following variables are then estimated: site index, age, volume (m^3ha^{-1}) and species composition. Additional variables may be estimated – *e.g.* diameter (breast height), height, stem density and wood quality – but they are not essential. The areas of the compartments are then calculated. Finally, operations to be carried out during the following 10 years are proposed. Hence, the plan includes a description as well as a suggestion for management (National Board of Forestry 2001b).

Aims

The management of the small-scale forest owners' is often undertaken by professional foresters, who have to consider the special requirements of the forest owners in order to propose suitable silvicultural practices. Considering the varying forestry conditions in different parts of the country and the changing attitudes among the heterogeneous group of small-scale forest owners is not an easy task. This work provides tools for analysing the objectives of the forest owners' and for giving proposals on suitable silvicultural practices for improving the management plan. In addition, it describes the decision process of the small-scale forest owners'. Thus, the following points describe the main aims of this thesis:

- To study the Green forest management plans from a policy and counselling aspect.
- To study how professional foresters choose areas set aside for nature conservation.
- To create a consistent theoretical framework that enables depictions and analysis of the objectives concerning actions that could actually be conducted as silvicultural practices. The model should also allow other proposed models in the field of forest science to be put into context.
- To conduct further studies on forest owners' objectives that elucidates the diversity among the owners.
- To identify different types of forest owners and quantify their objectives.
- To evaluate the suitability of different silvicultural practices for fulfilling multiple objectives and present a method for evaluating the results of research within the field.

Material and Methods

The work was intended for use as a foundation for decision-making by small-scale forest owners. The following approaches were chosen to meet the defined aims above (see Figure 3). Firstly, the current forest management plans were studied. The link between the policies at different levels – the inventory instruction – the counselling – the management plan and the forest owners was studied (Paper I). Compared to the old 'production-oriented' plan, nature conservation exerts a big influence on the Green plan. Therefore, the professional foresters' choice of areas set aside for nature conservation and how these compartments differ from production compartments were studied (Paper I). However, if the forest management plan should promote sustainability the proposed silvicultural practices should be based on the objectives of the forest owners.

A literature review was conducted to study the research within the scientific field of small-scale forest owners'. Within the literature, there was no consistent theory with connection to silvicultural practices, thus, such a theoretical model had to be constructed (Paper II). Further studies on forest owners' objectives were considered necessary and the theoretical model was used during the collection and analysis of the data from qualitative interviews with foresters and small-scale forest owners. This resulted in a qualitative model with motivations and objectives of the small-scale forest owners' (Paper II).

If the qualitative model is valid, it should be possible to create a typology of forest owners based on these ideas. Therefore, a quantitative study was performed using a survey to identify different types of forest owners and quantify their objectives (Paper III).

To be able to implement the objectives of the forest owners into forest management plans, the relationships between silvicultural practices and the objectives of the owners' had to be studied (Paper IV). A further literature review was undertaken, followed by an analysis of the relationships between silvicultural practices and the objectives of forest owners. In addition, a method for evaluating the results of research within the field is presented (Paper IV). The matrixes provided a systematic and theoretical means of describing a problem, for example allocating an index where there is lack of information.

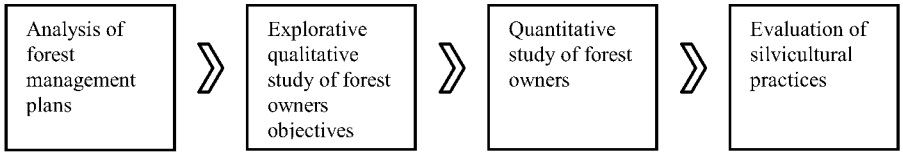


Figure 3. The methodological approach of the thesis.

Analysis of forest management plans, Paper I

In a Green Forest Management Plan, every compartment on productive forestland is assigned a goal class describing the direction of the long-term goals aimed at production or conservation. The National Board of Forestry placed a minimum level of 5% per estate for the areas set-aside for nature conservation (NO and NS), and in practice, all organisations have adopted this limit. This level has become a kind of political consensus, following the recommendations by FSC (Forest Stewardship Council) or/and PEFC (Pan-European Forest Certification). The recommendations also require considerations in the production compartments, such as green tree retention and a certain percentage of broad-leaved trees. The four goal classes in use are (National Board of Forestry 2001b):

PG - Production goal, with general environmental considerations
PF - Production goal, with reinforced environmental considerations
NS - Nature conservation goal, with management
NO - Nature conservation goal, based on no management

The policy documents and inventory instructions for the various organisations (organisations detailed below) were compiled and the contents were analysed with an emphasis on nature conservation. To provide information on the policy for consulting with the forest owner, two planners from each organisation were interviewed. Planners were asked to describe the scheme for planning and counselling. For a more detailed description of qualitative interview methodology, see chapter 'Qualitative studies, Paper II'.

Ninety forest management plans were sampled from five planning organisations (organisations detailed below) within Sweden. These organisations were chosen for the study as they were the largest plan producers, had been producing green forest management plans since 1998 and covered 80% of the total area of management planning in Sweden in 2000. The organisations included:

- The Forestry Board Organisation is the common name for the National Forestry Board and the Provincial Forestry Boards. The Forestry Board Organisation is a governmental organisation with the main objective of providing sound environmental management of forests according to the National forest policy.
- Södra is a forest owner association with almost 34,000 members with 2 M hectares of forest in the south of Sweden.
- Mellanskog is a forest owner association with more than 22,000 members, owning 1.5 M hectares of forest in central Sweden.
- Sydved AB is owned two-thirds by StoraEnso and one-third by Munksjö. Sydved works largely with small-scale forest owners supplying pulpwood to the owners' industries in the south of Sweden.
- Skogssällskapet is an independent foundation, which manages forest for private forest owners, municipalities and foundations. Skogssällskapet manages 450,000 hectares of forest for more than 1,000 owners.

The sample comprised of 90 estates from throughout Sweden with a total of 5223 compartments. The size of the estates varied between 11 ha and 660 ha. Ten percent of the compartments had goal classes NS or NO and the average size of each compartment was 2.4 ha. The material was further divided into two groups to determine differences between the north and south of the country.

Stepwise discriminant analysis identified statistically significant variables for discriminating goal classes. Goal classes PG and PF were considered as one class in the analyses, whereas NS and NO were differentiated because the criteria for defining them are different. Equal covariance matrixes were assumed, even if this was not completely fulfilled. Thus, a linear discriminant function was considered appropriate for examining how professional foresters chose areas set aside for nature conservation. The performance of the linear discriminant function was evaluated by estimating error rates (probabilities of misclassification) in the classification of future observations. Additional analyses of variances were performed for variables of special interest.

Qualitative studies, Paper II

Action-oriented theories were particularly useful as sources of inspiration for depicting motivations and objectives of small-scale forest owners'. Theories of action within social sciences are often related to action theory within philosophy. A classic view of action is for example represented in the so-called belief and desire (BD-) model (Moya 1990, Mele 1997, Petersson 2000).

Anthropology preserved a basic theory of action (*e.g.* Kuper 1996), which inspired and influenced the methodology of contemporary social sciences in general (Denzin & Lincoln 2000). A classical theory of culture was used for depicting underlying reasons for the management activities of small-scale forest owners. Within anthropology, practically oriented value-theory is essential to the concept of culture. According to Kroeber & Kluckhohn (1952), values are seen to guide subjects' interpretation of the "world" and of normative ideas for actions. For a detailed description of 'driving forces underlying actions', see Paper II. To represent culture as such a system, there was a need to define and identify traits on at least three levels: a) ideas concerning concrete actions and conditions for actions; b) ideas concerning types of actions; and c) ideas concerning actions in general terms. In the case of forest management, the first level can be exemplified by specific ideas on soil and water conservation that lead to certain silviculture practices being performed, for example using natural regeneration under shelter instead of clear cutting. The second level would reveal a persistent idea in favour of, as in this example, conservation, and the third level would accordingly reflect general ideas and mental tendencies in favour of a better environment.

Other studies on the utilisation of natural resources have also used action models, but with socio-psychology as a source of inspiration (Young & Reichenbach 1987, Beedell & Rehman 2000, Bieling 2003). These studies are founded on the Theory of Reasoned Action (TRA) (Ajzen & Fishbein 1980) or the 'Theory of Planned Behaviour' (TPB) (Ajzen 1985). The TPB is an extension of TRA. Central to the

theory is the individual's intentions to perform or not perform a given behaviour. TPB refers to generalized predisposition and to a specific behaviour context under perceived social pressure (Ajzen 1991). The focus is rather set upon attitudes towards actual behaviour than towards possible actions. In contrast, the anthropological framework of the present study focuses on the normative attitudes of the subjects and on general values among particular groups. The model assumes an interest in enhancing the opportunities for subjects to undertake new types of actions. The TPB-theory implies knowledge about how patterns of behaviour are spread among subjects; *e.g.* among forest owners and the forest professionals.

A qualitative interview method was used to explore the motivations and objectives of small-scale forest owners'. Qualitative data, with an emphasis on persons' experiences, are suitable for identifying attitudes towards events, processes and structures in their lives (Miles & Huberman 1994). The method is generally explorative, and the researcher has only preconceived ideas about the topics that should be discussed, thus interviews are open-ended (Patton 1990, Kvale 1996, Denzin & Lincoln 2000). The qualitative interviews were tape-recorded and lasted on average two hours.

During the first round of interviews, foresters working on a daily basis with forest owners were interviewed. These informants were chosen primarily for their wide-ranging experience of small-scale forest owners and forest management. This was assumed to indicate that they had reflected upon the objectives and motivations of the forest owners and that could express this in a structured way. The informants were asked to describe the small-scale forest owners' management situation of the past, present and future. Different forestry service organisations throughout Sweden (The Forestry Board Organisation, Holmen Skog AB, the Swedish Association for Hunting and Wildlife Management, Mellanskog, Skogssällskapet, SCA Forest Products AB, StoraEnso AB, Sydved AB and Södra) were represented. The selected informants worked with management services such as felling operations, forest conservation, forest administration, forest management plans, timber trading, forest policy, economic counselling and game management. Fourteen individual interviews with professional foresters were conducted during summer 2000.

Informants ensured that the researcher contacted people, situations and events that contributed to the progress of the research. However, there is also a risk that the researcher can rely on what the informants say rather than looking at the world through the eyes of the respondents (the forest owners) (Bryman 2001). Therefore, a second round of interviews was conducted. Eight National Board of Forestry districts throughout Sweden were asked to suggest 32 small-scale forest owners with special interest in conservation, production, amenities, economy or other specialities. This resulted in sixteen interviews conducted with forest owners during summer 2003. The forest owners were asked to describe their connection to forestry; their activities in the forest; and finally, their objectives were discussed.

In accordance with the method used by Miles & Huberman (1994), data reduction was used for focusing, sharpening and organising data that appeared in

the transcriptions. A coding scheme was devised to differentiate and combine the data: codes are tags used to identify specific themes in a text. The method for analysing the data from both the informants and the respondents was the same. The clusters represented motivations and the codes under the motivations represented the objectives of the small-scale forest owners'. Finally, the objectives were defined and empirical examples confirming the definitions were chosen from the data.

Quantitative survey, Paper III

A nationwide survey of small-scale private forest owners in Sweden was conducted during 2003. The population consisted of all private forest properties with forest holdings of between 5 and 8000 hectares. The random sample was stratified into four strata according to the properties' forest acreage (Table 1). For a more detailed study of the procedure, see Paper III. The response rate was 59.3%. The groups of respondents and non-respondents were compared to assess the statistical significance of differences between them. Some differences were significant, but were minor in absolute terms and were considered to have limited effects on the overall results of this study (see Paper III).

Table 1. The composition of the sample

Stratum (size)	Total distribution (N)	Sample (No.)	Sample proportion (%)	Respondents (No.)	Response rate (%)
5 - 24 ha	86474	333	0.39	193	58.0
25 - 99 ha	81370	906	1.11	559	61.7
100 - 399 ha	25395	625	2.46	366	58.6
≥400 ha	1880	158	8.40	81	51.3
Total	195119	2022	1.04	1199	59.3

The questionnaires included 25 questions concerning the forest owners' background, characteristics of their estates, forest management activities and the importance of their objectives. The respondents were asked to assess the importance of the 15 objectives of forest owners', according to the professional foresters surveyed in Paper II, on a five-point scale. The forest owners were also asked to predict the importance of each objective five years into the future. Examples of formulations of the questions and the considerations for improving the response rate are presented in Paper III.

Different agglomerative hierarchical clustering procedures were tested using the MINITAB software package (MINITAB 13:20 (2000)). Clustering of observations is used to classify observations into groups when the groups are not initially known. Different linkage methods determine how the distance between pairs of clusters is defined. The objectives of the owners' were grouped, by means of cluster analysis, according to their similarity in level of importance as stated by the respondents. Different linkage methods were tested, such as 'single linkage', 'average linkage' and 'Ward's linkage'. In addition, the statements about the 15 objectives were compared in pairs to study the differences identified in the cluster analyses.

To establish a typology of forest owners, cluster analysis was used to group the respondents based on their stated views of the importance of the objectives. It was desirable for the groups to be mutually exclusive rather than overlapping. Different methods were tested, but the characteristics of the observations appeared to work best with Ward's linkage method. This method has also been used by Pregernig (2001) and Boon *et al.* (2004) for determining typologies. After testing various numbers of clusters, it was found that five different clusters resulted in the most suitable typology of forest owners in Sweden. Analyses of variance were performed on owners and forest characteristics to validate the results of the cluster analysis and to facilitate comparisons with other studies.

Evaluation of forest practices, Paper IV

The theoretical model presented in Paper II, describing private forest owners' objectives, was used to compare the different practices. The relationships between practices and forest owners' objectives were analysed. The objective 'emotional tie' was not studied, because the lack of research in this area. 'Water conservation' and 'soil conservation' were considered as one objective, as the results from the analyses were the same. The results of the literature review were summarised in the form of matrixes, with the clusters of objectives on one-axis and silviculture practices on the other. One matrix was constructed for each cluster of objectives, *i.e.* 'conservation', 'amenities', 'utilities' and 'economic efficiency'. Each cell was allocated a level of adaptation and the levels were summarised using the following variables: A for adapted (1); P for partly adapted (0); and N for not adapted (-1). This part might be one of the most difficult parts of the thesis, considering that some results may be affected by a certain amount of subjectivity. Following Gustafsson (1998), a system for reviewing the references was used, allocating stars according to their validity:

*** Refereed articles or monographs
** Scientific reports and textbooks
* Inadequate reference

The star system maps the documented knowledge for the area under consideration, thus areas lacking research were apparent on the matrixes. In such cases, the evaluations were based upon interpolations and common knowledge. The suitability of each practice was evaluated individually and summarized. Horizontally, the summation included the scores for each individual practice. Vertically, the summation of practices demonstrated their suitability for each individual objective. Finally, the level of suitability for the multiple objectives of small-scale forest owners is presented. There are large numbers of forest owners, representing a wide variety of values, and for whom the different objectives assume different levels of importance. This is not taken into account in the summations, but a proposal for how to handle this issue is described under the heading 'Applications, Paper IV'.

The practices were analysed at forest stand level during a period of twenty years. This period was chosen for several reasons. First, properties tend to change owners

during such a period (Eriksson 1989a). Second, this period is a time suitable for surveying; after twenty years the forest has developed into a new age class and a new silvicultural practice is often necessary. In the Green management plan the productive forest area is divided into 20-year intervals, see Paper I. Over a longer period, it would be difficult to gain an overview. If the period considered were a rotation, the analysis would have been on the level of systems, rather than practices. The latter was not within the scope of this study, but a rough outline, with a comparison between two silvicultural systems is presented under the heading 'Applications, Paper IV'.

The stands referred to were assumed to have a history and pre treatment such that the practices would function without severe risk. The tree species were limited to Scots pine (*Pinus sylvestris*) and Norway spruce (*Picea abies*) in their natural habitat: other species could be kept in the stand for biodiversity purposes. Although the emphasis was on the most common practices related to clear cutting and uniform shelterwood systems (Matthews 1989), other practices, related to silvicultural systems in Central Europe that could be adapted to Scandinavia, were also analysed. The term 'silvicultural practices' refers to techniques for managing forest compartments such as felling, tending, regeneration, *etc.* They are, in general, active (felling, planting and burning), but there are exceptions (no felling, no cleaning). The definitions of the forestry practices examined are presented in Paper IV.

Results and Discussion

In this chapter, the result and discussion from each paper are presented simultaneously.

Policy, instructions and consultations, Paper I

The national forest policy objectives, accepted by the Swedish Parliament, have been made into concrete objectives by the National Board of Forestry in consultation with the forestry sector. All organisations describe their policy and forestry intention with reference to environmental and production goals: these goals should have equal status according to the first paragraph in the Forestry Act. The instruction for producing green forest management plans should be operative and follow the policy to become efficient. The description of nature values is a good foundation for discussions with landowners, and together they can assess the priorities for areas set aside for nature conservation according to the objectives of the forest owner. The organisations in this study had the possibility of producing a modified plan for certification by FSC or PEFC, and in compliance with this instruction, all organisations counted NS and NO as areas set aside for environmental reasons.

All organisations provided education in nature conservation for the professional foresters. The result of the interviews with the planners showed that consultation, acting as a link between the policy, the instruction, the forest management plan and the landowner, took place on several occasions: before and during the fieldwork, during the briefing of the preliminary plan and on delivery of the final plan. The time demands of the planning placed high pressure on the inventory staff. They did not often have the opportunity or time to present the management plan to the forest owners, especially the smaller ones. As exemplified by one professional forester: "Many forest owners do not live on their property and I can seldom bring the forest owner to the forest during the inventory, because time is short if the price per hectare (cost of developing plans) should be low." As a result, the forest owner did not always participate in the process of deciding goal classes.

Different planners had different methods for consulting; these differences were on an individual level rather than on an organisational level. For example, one forest planner said: "It is seldom that the goal classes are discussed as long as they do not exceed 5% (of the area of the estate) by too much" whereas another forester said "I always discuss the goal classes with the forest owners."

Areas set aside for nature conservation, Paper I

The goal classes NS and NO covered approximately 6.7% of the total productive forest area, corresponding to 7.0% of the standing volume in the plans studied. A majority of the plans had at least 5% of the productive forest area reserved for goal classes NS and NO. An attempt was made to define desired effects, from an nature conservation point of view, of the statistically significant variables according to the stepwise discriminant analysis (Table 2). The production goal was seen as the default class. For example, high natural values are often found in older forests with some gaps and dead wood. A high percentage of spruce often creates monocultures, but also dead wood. Broad-leaved forests frequently have high natural values and need to be managed to preserve that state.

Table 2. The desired effects

Variables	NO	NS
Broad-leaved trees (%)	low	high
Age (years)	high	high
Site index (m at 100 yr)	low	high
Volume (m^3/ha)	intermediate	intermediate
Area (ha)	high	high
Spruce (%)	intermediate	low
South/North	North	South

Three important factors were highlighted by the result of the linear discriminant function analysis (Table 3). The biggest problem with the analysis was to determine the difference between NS and NO. In many cases, it was not evident whether there should be management or not on the area set aside for nature conservation. Some of the production compartments were misclassified into nature conservation compartments. One reason for this might be that there were more compartments suitable for nature conservation than the forest owner wished to set aside. A few nature conservation compartments appeared to be misclassified into production. In these cases, there could have been a lack of suitable compartments for nature conservation.

Table 3. Forest stands classified into goal classes NO, NS and P, according to the linear discriminant function

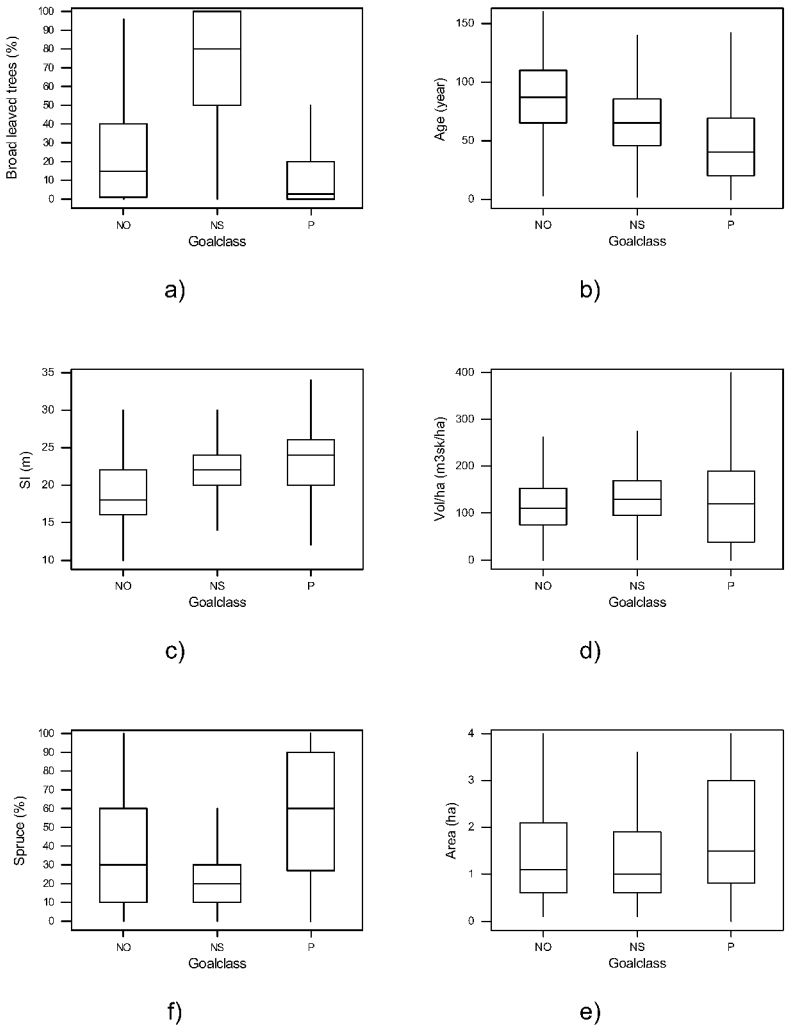
Goal class according to the planners	Goal class classification by linear discriminant analysis (%)			
	NO	NS	P	Total
NO	68.32	19.80	11.88	100.00
NS	22.0	70.00	8.00	100.00
P	14.26	10.76	74.98	100.00
TOTAL	17.95	13.21	68.84	100.00

Figure 4 shows the distribution of six out of seven significant variables. It is clear from Figure 4 (a) that the goal class NS had a considerably higher proportion of broad-leaved trees than the other goal classes. This was desirable from a nature conservation area perspective, (see Table 2).

A reason for the high proportion of broad-leaved trees in goal class NS might be that this goal class is predominant in southern Sweden, where most of the forest land is culturally influenced by a high proportion of grazing land and marshes with alder trees. Furthermore, the reason for the low proportion of broad-leaved trees in goal class P might be that up to about 1980 broad-leaved trees were considered less valuable and hence were removed in cleaning or first thinning.

NS and NO were generally older than compartments with a production goal (Figure 4 (b)). This could be due to compartments with older trees being more suited to nature conservation, whereas young forests are primarily established for production purposes. Compartments in goal class NO were generally older and had a lower site index than the other goal classes (Figure 4 (c)). The low site index for NO and the high median for NS were desirable. Figure 4 (d) shows that production compartments had a high proportion of young stands compared to the other goal classes. The proportion of total area and the average standing volume per hectare for the different goal and age classes are presented in Figures 4 and 5 in Paper I. The average volume per hectare increased with increasing age for all goal classes; however, this trend was not clear for compartments in class NO, possibly due to compartments being situated on poor sites with low standing volumes throughout the rotation period. Many of the compartments in goal class NO were also considered to be virgin forests with a balance between production of new and dead wood.

One reason for the low proportion of spruce in goal class NO (Figure 4 (f)), is that Sweden has two indigenous conifers, Norwegian Spruce (Picea abies) and Scots Pine (Pinus sylvestris). Pine is less productive on fertile soils but is dominant on poor soils. Furthermore, the expected lifetime of pine is much longer than spruce and the wood is more durable.



a) Proportion of broadleaf species (%), b) age (years), c) site index (m), d) volume (m^3/ha), e) compartment area (ha), and f) proportion of spruce (%), divided on goal classes

Figure 4. Boxplots of six variables divided by goal classes.

The proportion reserved for goal class NS was significantly higher in the south whereas goal class NO dominates in the north. The average area of the compartments in goal classes NS and NO was smaller than compartments in goal class P (Figure 4 (e)). This was undesirable for choosing nature conservation areas. One reason for this could be that compartments with production goals need to be of sufficient size and suitable shape for rational management. Another reason might be that areas of interest for nature conservation are often small and were previously included in production compartments.

The total share of area, as well as volume, for classes NS and NO were approximately the same in both southern and northern Sweden, with class NS more dominant in the South and class NO dominant in the North. NS was more frequent in southern Sweden due to better growing conditions. This is in line with regional classifications (Ahti *et al.* 1968, Sporrong *et al.* 1995) and recommendations from the National Board of Forestry (2001a). The forest management plan should take the objective of the forest owner into consideration and likewise the plan should give the forest owner the opportunity to consider the National forest policy. Therefore, the suggestions of goal classes in the forest management plans are not only dependent on the variables within the plan and other criteria are involved in the decision making for the professional forester, such as the occurrence of endangered species. The areas set aside for nature conservation are recommendations and because the Green forest management plans were only recently produced it is too early to predict the degree to which these will be followed by the small-scale forest owners. The Green management plan is adapted to the National forest policy, but it could be questioned if the Green management plan is adapted to the multi-objectives of the small-scale forest owners.

Theoretical framework, Paper II

In the model presented here, the normative ideas were divided into 'motivations' and 'objectives'. Corresponding interpretive ideas were divided into understandings and descriptions. Values represented the deepest aspect of the model, underlying both normative and interpretive traits. For studying the driving forces of small-scale forest owners, the motivations and objectives should be primarily considered and depicted. Thus, motivations, being rather general traits, concerned classes of actions; objectives concerned particular types of actions that could actually be performed, such as silvicultural practices.

In the model proposed, the notions – 'motivations' and 'objectives' for representing the driving forces of small-scale forest owners also affiliated with previously presented ideas (Kurtz & Lewis 1981, Bliss & Martin 1989, Lönnstedt & Törnqvist 1990, Lönnstedt 1997, Karppinen 1998b, Karppinen 2000). For a more detailed description of the theoretical model and discussion of the similarities between the model presented and other studies, see Paper II.

The theoretical model could be seen as a hierarchy of motivations and objectives of varying importance. On a subjective level, each forest owner will have an individual hierarchy of motivation. A theoretical model with distinctively different motivations will not exclude an interweaving of motivations, as forests are always valued in multiple ways, simultaneously (Bengston & Xu 1997). The model proposed by Bliss & Martin (1989) could be argued as an example of this, where the category 'motivations' represents traits from all three levels ('objectives', 'motivations' and fundamental 'values') according to the model presented here.

Qualitative interviews, Paper II

The following section summarises the trends among small-scale forest owners in Sweden according to these foresters. Due to current societal developments, many forest owners have jobs outside the forest business and the traditional forest owner working on their own property will soon be a minority. Membership in the European Union resulted in lower agricultural activity among farmers and today farm owners strictly performing forestry activities dominate. According to a professional forester, the value of the property could previously correspond to the return from the forest. It is believed the interest of timber production has not decreased, rather other interests are considered more highly than previously. Because of this, many farmers cannot compete on the property market. Many people wish to invest money in forest properties and one reason could be that owning land might give them possibilities for a better quality of life. Another reason might be that money invested in forest properties is not subjected to taxes on capital yield. Further more, it might be an advantage to invest in property before a change of generation. As exemplified by one professional forester: "The forest has not the same significance as in former days... Previously, forest owners bought land to increase the area of their own property. Today people buy a property for horses or hunting. Thereby the forest becomes a side issue and the reason for cutting will not be because of money."

The professional foresters highlight that the objective is still often economic efficiency, but other values now have to be considered. The interest in natural and cultural values on the property has increased and water conservation is now an important part of the planning for the small-scale forest owner. Many forest owners feel a strong responsibility for managing the land for previous and future generations. Owning a forest property can also be an irrefutable way of maintaining contact with one's native community. The motivations and objectives were described and structured according to the information given during the interviews. Four motivations emerged containing 15 abstracted objectives of small-scale forest owners in Sweden (Table 4).

Table 4. Small-scale forest owners' motivations and objectives according to the informants

Motivation/Objective	**Code**	**Motivation**/Objective	**Code**
Production	**P**	**Conservation**	**C**
Timber Production	Pt	Nature Conservation	Cn
Game Production	Pg	Cultural Conservation	Cc
Mushrooms and Berries Production	Pmb	Water Conservation	Cw
Forest Grazing Production	Pf	Soil Conservation	Cs
Amenities	**A**	**Economical efficiency**	**E**
Forestry Tradition	At	Yield of Capital	Ec
Challenge of Management	Am	Liquidity reserve	Er
Aesthetics	Aa	Annual Income	Ei
		Tax Planning	Et

The informants indicated a change in objectives from the 90's onwards; examples included the objectives under the motivation 'conservation' and 'tax planning'. 'Tax planning' is important for forest management planning in Sweden, for several reasons. Firstly, high income taxes may be transferred into lower capital interest taxes for the forest owner; secondly, investments in the private forest enterprise may reduce taxes because of favourable tax rules; and thirdly, forest properties are not subjected to taxes on capital yield. 'The position of owning land' was, however, not an objective according to this empirical model, as the objectives concern particular types of actions that could actually be conducted as silvicultural activities. Neither was 'recreation' an objective as it was considered included in several other objectives of the model *e.g.* 'game production', 'mushroom and berries' 'production', 'challenge of management' and 'aesthetics'.

The results from the first round of interviews were compared with the data set from the second round of interviews. The results from the first round appeared to cover most objectives according to the forest owners themselves. Four motivations emerged containing 16 abstracted objectives of small-scale forest owners in Sweden (Table 5).

Most objectives and definitions were kept from the results of the first round as they corresponded to the forest owners' opinions. 'Challenge of management' was renamed to 'challenge of silviculture' as it was more specifically related to the production of timber and mentioned more frequently by the forest owners than by the professionals. According to the forest owners 'timber production' was associated with the objectives 'challenge of management' and 'yield of capital'. Thereby the objective 'timber production' was not found in the results from the second round and the motivation 'production' was renamed to 'utilities'. It was also necessary to divide the objective 'mushrooms' and 'berries production'. The objective 'emotional tie' under the motivation 'amenities' differentiated the results of the second round from the first round.

Table 5. Small-scale forest owners' motivations and objectives according to the respondents

Motivation/Objective	**Code**	**Motivation**/Objective	**Code**
Utilities	**U**	**Conservation**	**C**
Game Production	Ug	Nature Conservation	Cn
Berries Production	Ub	Cultural Conservation	Cc
Mushrooms Production	Um	Water Conservation	Cw
Forest Grazing Production	Uf	Soil Conservation	Cs
Amenities	**A**	**Economical efficiency**	**E**
Emotional Tie	Ae	Yield of Capital	Ec
Forestry Tradition	At	Liquidity reserve	Er
Challenge of Silviculture	As	Annual Income	Ei
Aesthetics	Aa	Tax Planning	Et

The definitions of the objectives and empirical examples confirming them are presented in Paper II.

The interviews determined there are many objectives influencing forestry activities and the empirical results highlighted that the objectives and motivations of small-scale forest owners covered a broad field and indicated a move towards conservational interests. Amenities were an important motivation and should be considered during forest management planning for small-scale forest owners in Sweden. As legislation limits possible silvicultural activities, and could limit preferred silvicultural activities, it was assumed that foresters and forest owners objectives were influenced by this. For example in areas where reindeer husbandry is active all year round, the private forest owner is obliged to consult with the Sámi (the Lapp population) about suitable silvicultural practices (The National Board of Forestry 1994); however, this land-use pattern is geographically limited to northern Sweden.

The foresters' perceptions of forest owners objectives, in comparison to forest owners expressed ideas, indicated that the foresters could express the objectives of the forest owners'. It was reasonable to expect the foresters to be biased by their own values regarding forestry, making them unable to express other normative views (Hugosson 1999). However, another important feature of foresters' culture should also be acknowledged, that is a drive for 'correctness' and a 'straight forwardness': this implies the foresters should be very objective, even when it comes to opposing viewpoints. This could also explain why foresters were able to express different objectives. The interviews with the informants also illustrated how the foresters tended to describe the forest owners objectives in well-defined structures, whereas the forest owners themselves often expressed interrelations between objectives and were not as clear in their definitions. This could be interpreted in two ways. On one side, it could be consistent with a culturally related and exaggerated self-reliance when interpreting the forest owners' objectives. Alternatively, it could also be an indication of a true capacity to understand and pertinently express the views of the forest owners. For a discussion about the qualitative methodological approach, see Paper II.

The clusters of objectives, Paper III

In the questionnaire, the forest owners were asked to comment if any objectives were missing from the results of the previous qualitative study. This did not reveal any traits that were not mentioned in Paper II.

A dendrogram of the results of the cluster analyses of the forest owners' objectives is presented in Figure 4, in Paper III. The qualitative model for the different groups of objectives, presented in Table 4, was consistent with the proposed clusters identified in the cluster analysis, except for the group 'production'. The objectives 'timber production' and 'forest grazing' divided this group. The comparison in pairs confirmed the results of the cluster analysis, for example, it showed that about 70 percent of the respondents gave the same statements about the four 'conservation' objectives and the similarities between

'timber production' and the other 'production' objectives were small. According to the forest owners, presented in Paper II, 'timber production' was considered closely related to 'capital growth', resulting in 'timber production' being taken away from the structure of objectives according to the forest owners. Thus, the separation of that objective was supported by the earlier qualitative study. The analysis showed that the suggested model covered a wide range of objectives and that any additional objective must be considered rare among Swedish forest owners.

The clusters of forest owners, Paper III

The five clusters of forest owners were named according to how they ranked the different objectives (Figure 5).

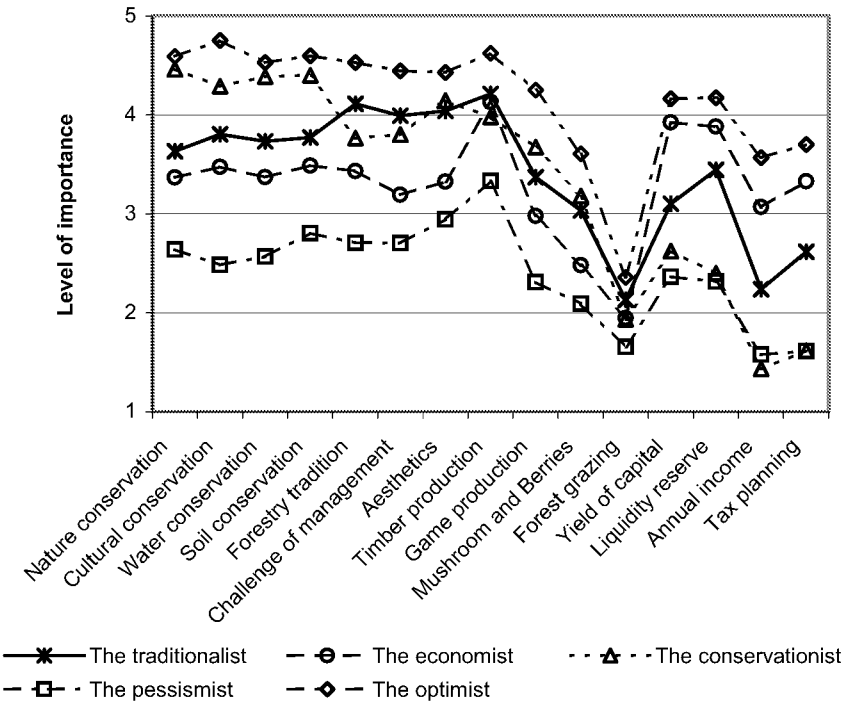


Figure 5. Results from the cluster analysis of the forest owners according to their stated views of the level of importance of the objectives (very important (5), not important (1)).

The cluster analysis model placed most forest owners (308) in 'the economists' group. The cluster of 'traditionalists' included 208 forest owners. 'The optimists' formed the smallest cluster with 129 forest owners, whereas 'the conservationists' and 'pessimists' included 174 and 191 owners, respectively. 'The economists' gave 'economic efficiency' the highest scores. 'The conservationists' were not motivated by financial concerns, but gave all 'the conservation' objectives high scores. 'The traditionalist' curve seemed to follow the mean curve of the five clusters, except for 'amenities', including the objective 'forestry tradition'. 'The

optimists' and 'the pessimists' were the least differentiated clusters. 'The optimists' found all objectives important, whereas 'the pessimists' gave lower ranking than the other clusters to all of the objectives.

Five different types of forest owners were identified solely using cluster analysis of the importance of objectives stated by the respondents themselves. This means that the respondents were able to discriminate between the different objectives and to express their differences. The clusters proved to have significantly different typologies, supporting the hypothesis that small-scale forest owners have become increasingly diversified (Marty *et al.* 1988, Karppinen 1998b, a.o.). This indicated that the qualitative model presented in Paper II is a useful tool for future research into forest owners' behaviour. Statistically significant characteristics separating the different types of small-scale forest owners' are presented below.

Cluster 1 – 'The traditionalist'

'The traditionalists' seemed to follow the mean value of all clusters of forest owners (Paper III, Table 4). Most had an estate with forest acreage of 25 to 99 hectares and lived in the municipality of the estate (Paper III, Table 5). On average, they were about 57 years old, the duration of ownership was slightly more than 20 years and more than 80% had acquired their holdings from the family. About half of the group lived on their respective estates, and the distance between their residence and their forest was on average barely 60 km. Most of 'the traditionalists' expected their children to take over their estates, and more than 10% of their income came from the forest for slightly more than a quarter of them. Slightly less than 40% of 'the traditionalists' had a forest management plan no older than ten years and a somewhat higher proportion would consider buying more land. 'The traditionalists' share characteristics with 'the Forest environmentalist' according to Kurtz & Lewis (1981), and some characteristics with 'the hobby owner' according to Boon *et al.* (2004).

Cluster 2 – 'The economist'

'The economists' lived on large estates and were relatively young. Most of them had grown up in the countryside, they had acquired their holdings from the family and they could consider, to a high degree, options other than letting their children take over their estates. The incomes from the forest were large, and half 'the economists' had a forest management plan. 'The economists' knowledge index, educational level and interest in buying more land were intermediate. 'The economist' is similar to 'the investor' of Karppinen (1998b), 'the timber producer' according to Kline *et al.* (2000) and shares some characteristics with 'the classic forest owner' according to Boon *et al.* (2004).

Cluster 3 – 'The conservationist'

'The conservationists' owned small estates, there was a large distance between their forest and their residence and the forest provided a very low proportion of their income. They were also somewhat younger, had owned the land for a relatively short time, and a small proportion of them had acquired their holdings

from their families. A significantly larger proportion of 'the conservationists', compared to the other clusters, had grown up in a city. 'The conservationists' knowledge index and educational level were intermediate. This group had little interest in buying more land. 'The conservationist' is comparable with 'the timber conservationist' according to Kurtz & Lewis (1981), 'the recreationist' by Karppinen (1998b), Kline *et al.* (2000) and 'the hobby owner' according to Boon. *et al.* (2004).

Cluster 4 – 'The pessimist'

'The pessimists' owned small estates, were older and a large proportion of them visited their estates less than 10 times per year. They expected their relatives to take over their estates to a lower degree than the other clusters. Few of 'the pessimists' had a forest management plan, and the forest rarely supplied more than 10% of their income. They also showed the least inclination to change the direction of land use, little interest in buying land and the lowest knowledge index. 'The pessimist' is similar to 'the passive owner' according to Kline *et al.* (2000) and 'the indifferent farmer' according to Boon *et al.* (2004).

Cluster 5 – 'The optimist'

'The optimists' lived on large estates with a long duration of ownership and expected their children to take over. They had grown up on the countryside, a large proportion of their income came from the forest and they were most interested in buying land. A change of direction was noted to a larger degree among 'the optimists' compared to the other clusters. The level of education seemed to be low, but on the other hand, they had a higher knowledge index than any of the other clusters. 'The optimists' also had the lowest percentage of women of the five clusters. 'The optimists' share many characteristics with 'the timber agriculturalist' according to Kurtz & Lewis (1981), 'the multi-objective owner' according to Karppinen (1998b) and Kline *et al.* (2000), and 'the classic owner' according to Boon *et al.* (2004).

The forest owners were asked about the future importance of each objective and most owners did not believe there would be a difference in five years time. Those who did believe there would be a difference (about 30% of the respondents), considered that the objectives of importance today would increase in importance in the future. This could possibly lead to larger differences developing between the groups. The most important reason for changes in forest owners' objectives is considered generational change, when people with different objectives, occupations and basic educational levels become forest owners through ownership transfers (Inglehart 1977, Karppinen 1998a). This was supported by the present study. The average ownership tenure in Sweden is 15-25 years (Eriksson 1989a).

Forest owners with different objectives may react differently with respect to certain forest policy issues. By studying Austrian forestry professionals, Pregernig (2001) showed that different types of forest owners respond to policy instruments in different, specific ways. Professional foresters in daily contact with the forest

owners can use the results of this study to identify different groups of owners. The results of Pregernig (2001) combined with the results of this study provided an opportunity for suggesting how forest owners in different clusters would respond to different policy instruments. For example, 'the optimist' could be influenced by regulatory instruments, whereas 'the pessimist' could be difficult to convince. 'The conservationist' is probably sceptical of many types of policy instruments. 'The traditionalists', holding an intermediate position, could be a good target group for several types of policy instruments. 'The economist' will probably follow policies if they are consistent with financial objectives. Professional foresters in daily contact with forest owners can use the results from this study to identify different owner groups. Future forestry management should be adapted to the forest owners' objectives shown in this and in similar studies. For a discussion about the weaknesses of surveys, see Paper III.

Evaluation of forest practices, Paper IV

In Paper IV, the result from the review of each motivation is presented, whereas in this summary only a short summary of the result for each matrix of motivations. In addition, the matrix with a summation of all objectives is presented in Table 6.

Natural regeneration under irregular shelter (NIS) and Natural regeneration at forest edges (NFE) appeared to be suitable for 'conservation' purposes. Absence of tending, clear cutting and successive felling produced low scores (see Table 1, Paper IV). The sum for the column 'culture conservation' was low. Thinning was the only practice appropriate for all three objectives within the motivation 'utilities' (see Table 2, Paper IV). Successive felling and cleaning were also useful, but inactivity was less appropriate. Successive felling, the main regeneration practices (especially different forms of shelter) and active tending were appropriate in supporting the objectives of 'the amenities' cluster (see Table 3, Paper IV). Clear cutting and passive practices were not appropriate. Successive felling, regeneration under different shelters, cleaning and thinning were well suited to 'economic efficiency' (see Table 4, Paper IV). Not cleaning had no 'economic efficiency' benefits.

Combining the results allowed an examination of the suitability of different practices for multipurpose forestry (Table 6). Thinning and natural regeneration under irregular shelter (NIS) produced the highest scores, indicating that they were the most adaptable practices. Natural regeneration under uniform shelter (NUS), natural regeneration at forest edges (NFE), cleaning and successive felling also indicated usefulness for multipurpose forestry. Clear-cut was less appropriate, and the least useful approach was passivity. The sum of the columns indicates the suitability of the practices for each of the clusters. The highest scores were for 'utilities' and 'amenities'; scores were lower for 'economic efficiency' and were especially low for 'conservation'.

The practices examined were suitable for forest owners who valued hunting, picking mushrooms, forestry traditions and aesthetics. 'Economic efficiency' did not achieve a high score. This may be because most of the practices considered

were regenerative, reduced liquidity reserves and required more than twenty years to produce a yield on investments. Another choice of model for describing the objectives of the forest owners would influence the results, as would a different choice of practices, however those presented here included the most common practices. The poor value for 'conservation' was mainly due to the low scores for 'culture conservation', indicating that forestry is difficult to combine with the protection of areas of high cultural value (Hasselmo 2000).

Table 6. A summary of the level of suitability of various practices for the four clusters of objectives

All clusters of objectives	Conservation	Utilities	Amenities	Economic efficiency	Sum
Clear cutting	-1	1	-2	1	-1
Successive felling	-1	2	3	3	7
No felling	-1	-1	-1	-1	-4
Scarification	0	1	-1	0	0
Burning	0	1	1	-1	1
Planting	0	1	1	-1	1
Sowing	0	1	2	-1	2
NUS	0	1	3	3	7
NIS	2	1	3	2	8
NFE	2	1	2	2	7
Cleaning	1	2	2	2	7
No cleaning	-1	1	-2	-3	-5
Thinning	1	3	3	3	10
No thinning	-1	-1	-2	-1	-5
Sum	1	14	12	8	35
Inadequately documented (%)	2.0	26.2	14.3	28.6	Mean: 17.9

Tree species could influence the evaluation, but a focus on pine and spruce along with the prerequisites relating to risks resulted in small differences. For example, clear cutting was equally negative for soil and water conservation irrespective of tree species. Pine is preferable when producing game fodder and berries, but the structure and density of the stand has probably a bigger impact (Kardell & Eriksson 1983).

The ranking presented here was based on interpretations from available literature on research within the field. It was presumed that the forest owner's opinions did not differ from the general views (Mörk 2000). There was also lack of information on practices such as natural regeneration under irregular shelter (NIS) and natural regeneration at forest edges (NFE) under Scandinavian conditions. The objectives 'game production' and 'aesthetics' were well covered in the literature, but the remaining objectives require further study. Consequently, the evaluations from the matrixes may be affected by a certain amount of subjectivity, reflecting the cultural background of the authors. The documented references (more than one star) covered 80% of the evaluations. Most cases with no documented references fell in the clusters 'economic efficiency' (29%) and 'utilities' 26%, indicating more

uncertainty associated with results of these two clusters compared to the 'amenities' and 'conservation' clusters.

All multiple objectives do not necessarily have to be taken into consideration in the same area. In practice, depending upon for example natural conditions, the objectives could differ in different parts of the estate, and thus the most suitable silvicultural practices. For a forest owner, each objective also has a different degree of importance; these could not be considered during the summation of objectives within the clusters. The matrixes provided a systematic and theoretical means of describing a problem, for example allocating an index even where there was lack of information. An alternative method would have been to evaluate the practices by means of case studies of well-defined compartments and categories of forest owners. This would have been advantageous in that there would be precise descriptions for each compartment and of the preferences of each category of owner, but a lack of literature would remain. Presumably, this would also be subjective as there would be fewer samples and the cross section may not be representative of the whole.

Applications, Paper IV

A time frame of twenty years for the analysis also influenced the results: this is a short period for changes within the forest. However, analyses over a longer period demand consideration of complete silvicultural systems, which was not the aim of this study. Despite these limitations, it was necessary to begin at the stand level in order to evaluate different systems, *e.g.* clear cutting and selection systems. The ranking system might be applied when a forest owner, with a definite profile, requests an evaluation of a complete silvicultural system for a compartment and over a whole rotation period. Below is an example where a forest owner with an ecological and nature-oriented profile might leave the compartment free to be influenced by natural processes. This hypothetical owner is interested in studying how the practices affect nature and water/soil conservation, in collecting edible mushrooms, in encouraging game and in tax planning. In Alternative 1 (Table 7), the owner chose to avoid active management during the whole rotation and to employ burning. In Alternative 2, a more active and traditional strategy was chosen by the owner.

The relative positions could be taken into consideration by allocating higher, perhaps double, scores to the more important objectives. This would make the two alternatives equally valuable. Thus, it is possible to adapt the choice of practices to the relative importance of different objectives. However, an evaluation at stand level may not provide sufficient information for decision-making at estate level. The composition of the stands, the structure and prior tending, all influence the outcome of favourable practices at estate level.

Table 7. Two examples of interactions between several practices in systems (scores from Tables 1-2)

Alternative 1.	Nature conservation	Water/Soil conservation	Mushroom production	Game production	Tax planning	Sum
No felling	0	0	1	-1	0	
Burning	1	0	0	1	1	
No cleaning	0	0	1	1	1	
No thinning	0	0	1	-1	0	
Sum	1	0	3	0	2	6
Alternative 2.						
Clear cutting	0	-1	-1	1	1	
Planting	0	1	0	1	1	
Cleaning	0	1	1	0	1	
Thinning	0	1	1	1	1	
Sum	0	2	1	3	4	10

General remarks and conclusions

The decision processes of small-scale forest owners

During the course of the research on small-scale forest owners, an image of their decision processes emerged (Figure 6). The theoretical framework, presented in Paper II, represents the heart of the processes. Important for this conceptualisation of culture is that it is seen as emerging over time. Values represent traits that are more stable over time than the motivations, which are more stable over time than the objectives. Each influence or resource could be seen as specifically related to one of the four traits presented in Figure 6. However, the decision processes occur simultaneously within subjects and the correct causal order may be difficult to establish. It should be noticed that 'counselling' is the only factor presented both as an 'external influence' and as 'the forest owners resource'. Today counselling often works as an external influence. In the future, it is necessary that foresters become a resource of the forest owners' by helping them recognize different objectives and thereby suggesting suitable silvicultural practices.

There has been a tradition among professional foresters to emphasise the role of influencing the forest owners in certain directions, *i.e.* traditional production oriented forestry. The results from Paper II indicated there is a true capacity among professionals to understand and pertinently express the views of the forest owners. With proper education, the foresters should be able to express the objectives of the forest owners and thereby construct an adapted management plan suggesting suitable silvicultural practices. This is an ideal opportunity for developing knowledge of alternative silvicultural practices among the foresters. Thereby the professional foresters would be a true resource for small-scale forest owners in promoting successful sustainable forest management.

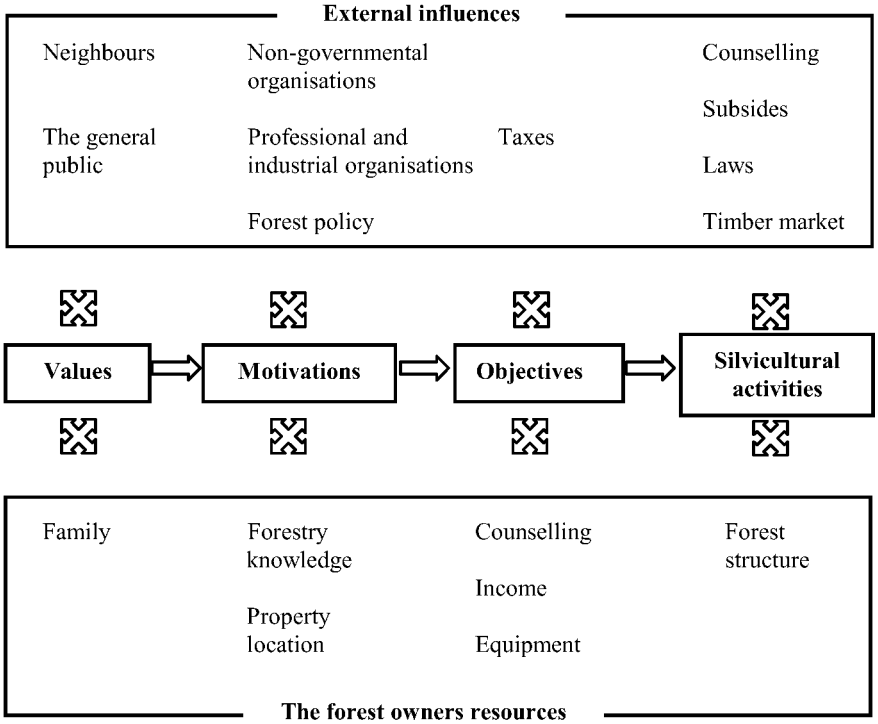


Figure 6. Factors affecting the decision process of the small-scale forest owners.

Future forest management plans

Today about one third of forest owners have a plan no older than ten years (Ingemarson unpublished data). The Green forest management plan is still characterized by the culture of the professional foresters, although it is a result of development work by the National Board of Forestry and influenced by the changing societal attitudes. 'Nature conservation' and 'economic efficiency' dominate the proposals in the plan, although 'water management' and 'culture conservation' could be taken into consideration. The 'modern' forest owners demand further developments of the management plan. A natural step would be to develop the instructions to the planners, so that the core of the plan will be the objectives of the forest owners'. The plan could address a few objectives of importance or be adapted to multi-objectives, *i.e.* following the presented motivations: 'amenities', 'utilities', 'economic efficiency' and 'conservation'.

Paper IV was prepared as a handbook of silvicultural practices that could be adapted for the different objectives of the forest owners'. This will probably lead to more active silviculture among small-scale forest owners', as suggested by Karppinen (1998a, a.o.). A 'multi-objective plan' could be developed where different parts of the property have different motivations. The management can be

divided into different zones, depending on for example the distance to houses or recreational areas. In the nearest compartments, 'amenities' and 'conservation' could guide the direction of the silviculture. In the next zone 'utilities' and even further away 'economic efficiency'. In practice, different considerations are already made close to houses and recreational areas, especially in community forestry, but this should be taken into consideration also for small-scale forestry. Alternative silvicultural practices can be taken into consideration to fulfil these objectives. It is important to inform forest owners about these possibilities to fulfil their objectives, which can be done through counselling, information campaigns and education.

Conclusions and further research

The indications are that the Green forest management plans have complied with changes in the new National forest policy in Sweden. To determine if the Green forest management plan really works as a policy tool it is necessary to investigate the degree to which the guidelines in the plan will be followed by the small-scale forest owners. This requires a follow up out in the field.

The contact between professional foresters and the forest owner is a weak point during the production of the plan, and differs little between the organisations studied. Further qualitative interviews are necessary to analyse the interaction between the planners and the forest owners while choosing areas set aside for nature conservation. Economic consideration did not appear the major consideration for the planners in the selection of nature conservation compartments in the Green forest management plan. Nevertheless, further studies, are necessary to ascertain that selection of stands is ecologically correct. The selection could depend on the education of the planners and the time set aside for the inventory. Some field tests have already been conducted, *e.g.* by Persson and Norstedt (2003). Although the study is limited to north Sweden, it showed that planners do not set aside all suitable compartments for nature conservation.

Most studies on forest owners objectives are more society-oriented, whereas this thesis focused more on the forest owners situation. Thereby, forest owners with differing views on forestry were the focus. The interviews and the survey also determined that the objectives and motivations of small-scale forest owners of today covered a broad field from nature conservation to tax planning. If the owners are aware of suitable silvicultural practices for multi-purpose forestry, it will be possible to determine if their choice of practices is in accordance with their objectives. It is also crucial to continuously monitor the preferences of the small-scale forest owners', due to the continual change of structure.

The theoretical model presented here could be considered a suitable tool for depicting both the motivations and objectives of forest owners and for making comparisons with forthcoming work. The results also indicated that professional foresters have the ability to understand and clearly express the views of the forest owners, but the foresters' culture seems to be a limiting factor. The social

relationship between these categories requires further study and then the 'Theory of Planned Behaviour' (TPB) could be a point of departure.

Clear sub-groups of forest owners' can be differentiated by their objectives. The quantification of the background variables of the clusters was successful, which is crucial for application of the results (Karppinen 1998b). The results confirmed recent studies (Bengston and Xu 1997, Karpinnen 1998a *a.o*) that a sole emphasis on economic benefits was not desirable from the forest owners' point of view. However, further information on preferences of the different clusters with regard to silvicultural management activities, levels of cuttings and the influence of different policy tools is needed.

To adapt the plan for multi-purpose forestry it is necessary to suggest appropriate practices. The tool in Paper IV provides an opportunity to suggest suitable silvicultural practices to different types of forest owners, for example the five clusters presented in Paper III. Useful practices for the 'the traditionalist' seem to be successive felling, natural regeneration under irregular shelter (NIS) and thinning. 'The economist' would be advised to use successive felling, natural regeneration under uniform shelter (NUS) and thinning. 'The conservations' would have benefit from using natural regeneration at forest edges (NFE), cleaning and thinning. 'The optimists' and 'the pessimists' were the least differentiated clusters and thereby the hardest clusters to recommend. 'The optimist', though, is a multi-objective owner and thereby the most suitable practices for multipurpose forestry would be recommendable. Thereby successive felling, NIS and thinning would be appropriate choices.

The results also indicate that thinning is the most useful forestry practice for private forest owners, although different forms of natural regeneration and cleaning are also appropriate. Passive practices seem to be unsuitable for the multiple objectives of small-scale forest owners. The relationship between forestry practices and objectives in general requires further study, for example with respect to liquidity reserve, tax planning, silvicultural challenges and berry and mushroom production.

Future research could focus upon developing priority functions, showing how the differing importance of the objectives could be taken into consideration while choosing a suitable forest management plan alternative. Kangas (1992) uses a decision analysis method called the Analytic Hierarchy process (AHP), and applies a linear function for weighting different multiple criteria for choosing the most satisfactory planning alternative for the forest owner. According to Kangas (1992), a proper function would look something like:

$$U = P_1u_C + P_2u_A + P_4u_E$$

Where $P_i = 1, 2, 3$ is the weight of the objectives u_j, $j = C, A, E$; $P_1 + P_2 + P_3 = 1$; u_C is the utility obtained from for example 'nature conservation' ; u_A is the utility obtained from 'forest tradition' ; u_E is the utility obtained from 'yield of capital'.

Priority functions could present the optimal solutions for different owners, but additive linear functions are also limited, for example, the functions assume additive effects of objectives and linearity as regards estimated weights. How to operationalise the criteria is also a problem.

Although the results show that forest owners can be differentiated by their objectives, more importantly the results show that more precise individual silvicultural programmes and alternatives can be created for each forest owner, than the ones developed according to the standard procedure. The results also indicate that the practices evaluated provide opportunities to adapt the forest management plan to multi-purpose objectives. Although the results are essentially restricted to Sweden, the research methods probably have broader applications for the forestry sector in general.

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Nature Conservation in Forest Management Plans for Small-scale Forestry in Sweden

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This article examines how professional foresters choose areas set aside for nature conservation and studies how these compartments differ from production compartments in Green Forest Management Plans for small-scale forestry in Sweden. The implementation of the forest management plans is supposed to lead to the desired policy outcomes. However, there has been a concern from several stakeholders that economic considerations could weigh too heavily. Observations from about 5000 compartments have been analysed at the estate and compartment level using discriminant analysis and descriptive statistics. The discriminant analyses highlight that planners mainly use the data in the plan to propose goal classes. Most variables studied were within the desired ranges for the areas set aside for nature conservation, for example age, volume and percentage of broad-leaved trees. However, the compartments set side for nature conservation were generally too small. In the south of Sweden the goal class 'Nature conservation goal with management' dominated, whereas the goal class 'Nature conservation goal based on no management' dominated in the north. Economic aspects were not found to be a major consideration when the planners selected compartments for nature conservation and the plans appear to comply with the new Swedish forest policy.

Keywords: nature conservation, forest policy, forest management plans

THE DEVELOPMENT OF GREEN FOREST MANAGEMENT PLANS

During the 1980s, discussion about forestry as a major cause for the depletion of biological diversity intensified. The Bruntland report (World Commission on Environment and Development 1987) placed the issue on the international agenda. At the UN conference in Rio de Janeiro in 1992 (United Nations 1992), the final statement included ambitions towards a sustainable society in general and maintenance of biological diversity in particular. These discussions influenced attitudes of forest companies and the public in Sweden: most forest companies and forest owner associations started to investigate how to handle this issue and several

projects were initiated in which expertise on forest management and biological diversity was applied in an effort to combine the various goals (Rülcker *et al.* 1994, Dahlin and Sallnäs 1994).

Changing attitudes came to political manifestation as the new *Forestry Act* passed by the Swedish parliament came into force in 1994. The first paragraph of this Act (National Board of Forestry 1994, p. 8) stated: 'The forest is a National resource. It shall be managed in such a way as to provide a valuable yield and at the same time preserve biodiversity. Forest management shall also take into account other public interests'. At the same time, the regulations of the Act are less detailed than in its predecessor, leaving decisions largely to the forest owner. One example is the lowering of the minimum age required for final felling. In the previous Act, a forest management plan was required, whereas the *Forestry Act* of 1994 requires only a description of the forest.

With about 350,000 Swedish forest owners and an average estate size of about 50 ha, small-scale forest (sometimes referred to as non-industrial, smallholder or family forest (Harrison *et al.* 2002)) holdings encompass about 50% of the total forest area in Sweden (National Board of Forestry 2001a). In the south of Sweden, properties are smaller with a greater biological diversity compared to the north, mostly due to differences in climate. The small-scale forest owners are diverse as a group, with objectives covering a broad field from timber production to environmental conservation and amenities (Hugosson and Ingemarson 2003).

Forest management plans in Sweden are mostly made by public agencies. Briefly, a plan is developed first by identifying and delineating compartments on a map with the help of aerial photographs and field control. Then for each compartment, averages for the following variables are estimated: site index, age, volume (m^3/ha) and species composition. Additional variables may be estimated – e.g. diameter (breast height), height, stem density and wood quality – but they are not essential. The areas of compartments are then calculated. Finally, operations to be carried out during the following 10 years are proposed. Hence, the plan includes a description as well as a suggestion for management (National Board of Forestry 2001b).

When the new *Forestry Act* was passed, the National Board of Forestry began development work with green Forest Management Plans; simultaneously, other organisations were working with corresponding plans. The goal of a green forest management plan is to produce a comprehensive picture of production and environmental conditions of the property and to provide management proposals resulting in sustainable forestry. A commission to produce a plan provides an opportunity for implementing forest policy intentions in the management proposals. Contracted by the forest owner, the organisation produces the plan, and provides information and consultation. As a result of the development work with green forest management plans, a new variable describing a goal class for each compartment was added to the plan. In a green forest management plan, every compartment on productive forestland (forestland which can produce an average of at least 1m^3/ha per year over the rotation period of the compartment) is assigned a goal class describing the direction of the long-term goals aimed at production or conservation. The goal classes express advice to the landowner on how the forest compartments should or could develop in the long term, and are supposed to be valid over several plan periods (one plan period is normally 10 years). Compartments with nature conservation goals are often given a more detailed description than compartments

with production goals. The four goal classes in use are (National Board of Forestry 2001b):

- PG - Production goal, with general environmental considerations
- PF - Production goal, with reinforced environmental considerations
- NS - Nature conservation goal, with management
- NO - Nature conservation goal, based on no management

In compartments with nature conservation goal with management (NS):

> environmental goals direct the nature conservation oriented management. The stand has high environmental values that require recurrent management activities to be preserved, or there are conditions present that allow the stand to return to similar high environmental values (National Board of Forestry 1999, p. 55.).

In compartments with nature conservation goal based on no management (NO):

> the environmental goals are enhanced by free development. The stand has high environmental values that require it to be left untouched in order for it to be maintained or there are conditions present that allow the stand to return to similar high environmental values (National Board of Forestry 1999, p. 55.).

The management of NS may bring economic benefit, but that is not the main goal. The National Board of Forestry placed a minimum level of 5% per estate for the combined goal classes NS and NO, and in practice all organisations have adopted this limit. The level is a kind of political consensus, following the recommendations of FSC (Forest Stewardship Council) and PEFC (Pan-European Forest Certification).

The environmental goals of the national policy require nature conservation actions. These actions are addressed in the green forest management plans. The implementation of the forest management plans is supposed to lead to the desired result of the policy. However, there has been a concern from several stakeholders that economic consideration could weigh too heavily. The green management plan highlights the nature values of the property, leading to improved possibilities for selling the timber. Even if the area goal of 5% is fulfilled, the compartments for nature conservation may not be chosen primarily to maintain the biodiversity but rather to minimise the economic loss of the set-asides.

The aim of this article is to examine how professional foresters choose areas set aside for nature conservation and to study how these compartments differ from production compartments in green forest management plans for small-scale forestry in Sweden. If implementation of the policy results in the desired effect then conservation aspects must have been more decisive than economic aspects when choosing the compartments to be set aside for nature conservation. This study did not examine the economic value of the different compartments and the natural values of the compartments were not studied in the field. It concentrated on some important variables which can be found in a green management plan, including age, area, percent of broad-leaved trees, percent of spruce, region, site index and volume.

RESEARCH METHOD

Ninety forest management plans were sampled from five planning organisations in Sweden. The policy documents and inventory instructions for the organisations were compiled and the contents were analysed, with emphasis on nature conservation. To provide information on the policy for consulting with the forest owner, two planners from each organisation were interviewed in order to study the counselling concept to the forest owner. Furthermore, the person responsible for the green forest management plans within each organisation were interviewed. Planners were asked to describe the scheme for planning and counselling. At the end of each interview, the researcher verified his understanding of the informant's statements and asked for amendments, following the method used by Kvale (1996). The interviews lasted on average for two hours and were tape-recorded, typed and analysed. Data reduction was used in focusing, sharpening and organising the data, and was conducted in accordance with the method used by Miles and Huberman (1994). Empirical examples were chosen to highlight the experiences of the professional foresters.

Spatial Distribution of the Sample of Forest Management Plans

The five planning organisations were selected on the basis that they were the largest plan producers, they had been producing green forest management plans since 1998 and they covered 80% of the total area of management planning in Sweden in year 2000. The organisations were:

- The Forestry Board Organisation, the common name for the National Forestry Board and the Provincial Forestry Boards. This is a governmental organisation with the main objective of providing correct and sound environmental management of forests according to the directives of the government and parliament. The Forestry Board Organisation produced plans for 227,000 ha in year 2000 and contributed 20 plans to the study.
- Södra, a forest owner association with almost 34,000 members in the south of Sweden, which owns 2 M ha of forest. Södra planned 200,000 ha during year 2000 and contributed 20 plans to the study.
- Mellanskog, a forest owner association working in central Sweden, which has more than 22,000 members owning 1.5 M ha of forest. They planned 80,000 ha during year 2000 and contributed 10 plans to the study.
- Sydved AB, owned two-thirds by StoraEnso and one-third by Munksjö, works largely with small-scale forest owners supplying pulpwood to the owners' industries in the south of Sweden. Sydved planned 35,000 ha in year 2000 and contributed 20 plans to the study.
- Skogssällskapet, an independent foundation, which manages forest for private forest owners, municipalities and foundations. Skogssällskapet manages 450,000 ha of forest for more than 1,000 owners. The foundation planned about 30,000 ha during the year 2000 and contributed 20 plans to the study.

The sample included estates from throughout Sweden; however, because small-scale forest owners are more prevalent in the south a greater number of plans was drawn from this area. In total, the area covered was 12,500 ha, corresponding to 2% of the area planned in Sweden in year 2000. The estates varied in size between 11 ha and

660 ha. Of the 5223 compartments, 10% had goal classes NS or NO and the average size of each compartment was 2.4 ha. The sample was further divided into two groups to determine differences between the north and south of the country. Forestry in North Sweden is dominated by forest companies and small scale forestry has less significance. Consequently, a smaller number of plans were choosen from the north of Sweden; out of the 90 plans 19 came from the north, representing 42% of the area. The river Dalälven (Limes Norrlandicus), about 150 km north of Stockholm, was used as the border between the two groups (Figure 1).

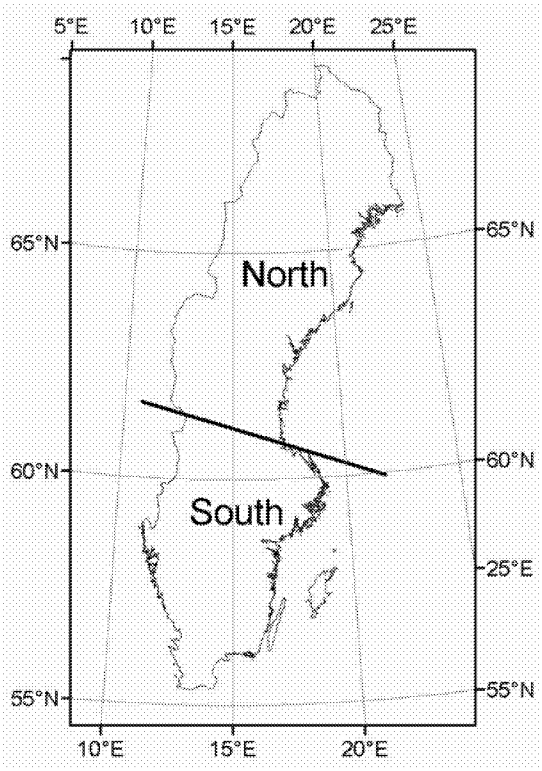

Figure 1. Map of Sweden with the north-south delimination indicated

Goal classes PG and PF were considered as one class in the analyses, whereas NS and NO were differentiated because the criteria for defining them differs. The productive forest area is divided into 20 year age intervals.

Discriminant Analysis and Statistical Methods

Discriminant analysis was adopted because a facility was needed for classifying observations, and the groups of goal classes were known *a priori.* Initial interest centred on variables as possibilities for distinguishing between classes. A question was whether some subsets of the original variables could provide a classification rule equal in performance to the rule based on using all available variables. A discriminant analysis procedure (Discrim) in the SAS statistical package (SAS Institute Inc. 1999) was used for the statistical tests.

Stepwise discriminant analysis was used to identify significant variables for discriminating goal classes. The model used a measure of 'separability' of groups and began with all available variables, and sequentially eliminated those for which the removal led to the least reduction in separation. Seven variables were analysed from the sample, namely percentage of broadleaf species of the basal area, age, site index, volume per hectare, location in the south or the north of Sweden, area, and the percentage of spruce of the basal area. The three class levels were Nature conservation goal with management (NS), Nature conservation goal based on no management (NO) and Production goal (PG and PF). The significance level to enter or stay was 0.15.

The assumption of equal covariance matrices was used, even if this was not completely fulfilled. A linear discriminant function was considered appropriate for examining how professional foresters chose areas set aside for nature conservation.[1] The discriminant function is determined by a measure of generalised squared distance (Rao 1973). An observation is classified into a group if the squared distance of observation to the group centre is the minimum. There is a unique part of the squared distance formula for each group and this is called the linear discriminant function for that group. The coefficient vector and constant used by the linear discriminant function is shown below, where $\overline{X}_j$ is the vector of mean values for group j:

$$\text{Coefficient Vector} = \text{COV}^{-1}\overline{X}_j$$

$$\text{Constant} = -0.5\ \overline{\text{X}}_\text{j}^{'}\ \text{COV}^{-1}\overline{X}_j$$

The performance of the linear discriminant function was evaluated by estimating error rates (probabilities of misclassification) in the classification of future observations. The different goal classes had equal probabilities. The observed probabilities would have resulted in a better solution for the whole dataset but with increased misclassification for the smaller classes NO and NS. The data of 5233 compartments was divided into two datasets. The derived linear discriminant function from the first subset was applied to a second subset, a calibration set, and the hence misclassification figures derived Additional analyses of variances were performed for variables of special interest. A significance test was made firstly, on the differences in average compartment area, for compartment with nature conservation and production goals and secondly, on the differences in average forest area per management plan, reserved for the goal classes NS and NO in southern and northern Sweden.

An attempt was made to define desired effects, from an nature conservation point of view, prior to the stepwise discriminant analysis (Table 1). The production goal was seen as the default class. NS and NO were given the desired effects – low, intermediate, high, south or north. For example, high natural values are often found in older forests with some gaps and dead wood. A high percentage of spruce often

[1] If the covariance of the two groups had differed, the discrimination rule would have been more complex, and a quadratic discriminant function would have been used. This was also tested but did not radically change the result and did not produce any better solution.

creates monocultures, but also dead wood. Broad-leaved forests frequently have high natural values and need to be managed to preserve that state. In the southern part of the country, the site index was generally higher, indicating management is needed to preserve that state.

Table 1. The desired effects for an analysis of the significant variables according to the stepwise discriminant analysis

Variable	NO	NS
Broad-leaved trees (%)	Low	High
Age (years)	High	High
Site index (height in m at 100 yrs)	Low	High
Volume (m^3/ha)	Intermediate	Intermediate
Area (ha)	High	High
Spruce (%)	Intermediate	Low
South/North	North	South

RESULTS

The results section firstly presents the policy, instructions and consultations connected to the production of a green forest management plan. Thereafter, the other sections present the results for the areas set aside for nature conservation on estate and compartment level.

Policy, Instructions and Consultations

The national forest policy objectives, accepted by the Swedish Parliament, have been made into concrete objectives by the National Board of Forestry in consultation with the forestry sector. The current situation and the objective for year 2003 were described under each sector objective. All organisations describe their policy and forestry intention with reference to environmental and production goals: these goals should have equal status according to the first paragraph in the *Forestry Act*. The National Board of Forestry has presented the clearest and most detailed policy, containing intermediate goals for both internal and external use, and including a description of the goal of the green forest management plans.

The instruction for producing a green forest management plan should be operative and follow the policy to become efficient. Concerning the disposition and formulations in the instructions, it appears that all organisations have incorporated the instruction of the National Board of Forestry. For all organisations, the definitions of goal classes follow the National Board of Forestry's instruction. The description of nature values consists of a description of the occurrence of nature values, which refers to species, structures and topography important for sustainable forest management, and contains at least one description of nature values for nature conservation compartments. However, the descriptions display great differences in degree of detail between different planners. The organisations in the study had the possibility of producing a modified plan for certification by FSC or PEFC, and in

compliance with this instruction, all organisations counted NS and NO as areas set aside for environmental reasons.

Consultations, acting as a link between the policy, the instruction, the forest management plan and the landowner, took place on several occasions: before and during the fieldwork, during the briefing of the preliminary plan and at delivery of the final plan. The time demands of the planning placed high pressure on the inventory staff. They often did not have the opportunity or time to present the management plan to the forest owners, especially those with small forest areas. As exemplified by one professional forester: 'Many forest owners do not live on their property and I can seldom bring the forest owner to the forest during the inventory, because time is short if the price per hectare (cost of developing plans) should be low.' As a result, the forest owner did not always participate in the process of deciding goal classes.

Different planners had different methods for consulting; these differences were on an individual level rather than on an organisational level. For example, one forest planner said: 'It is seldom that the goal classes are discussed as long as they do not exceed 5% (of the area of the estate) by too much.' while another forester said 'I always discuss the goal classes with the forest owners.' Sometimes there is a conflict between economic and nature values, as exemplified by an empirical example: 'generally, few conflicts between economic and nature values arise … they appear in areas were the forest owner cannot see the nature value of, for example, a coniferous forest with one third of aspen.'

Nature Conservation on Estate Level

The goal classes NS and NO covered approximately 6.7% of the total productive forest area, corresponding to 7.0% of the standing volume in the plans studied, as reported in Table 2.

Table 2. Forest area and standing volume distribution over the various goal classes

Goal class	P	NS	NO
Proportion of forest area (%)	93.3	2.4	4.3
Proportion of standing volume (%)	93.0	2.9	4.1

A majority of the plans had at least 5% of the productive forest area reserved for goal classes NS and NO (Figure 2). Nineteen of the plans (21%) classified less than 5% of the area to goal classes NS and NO, and 5 plans had no areas reserved for these goal classes.

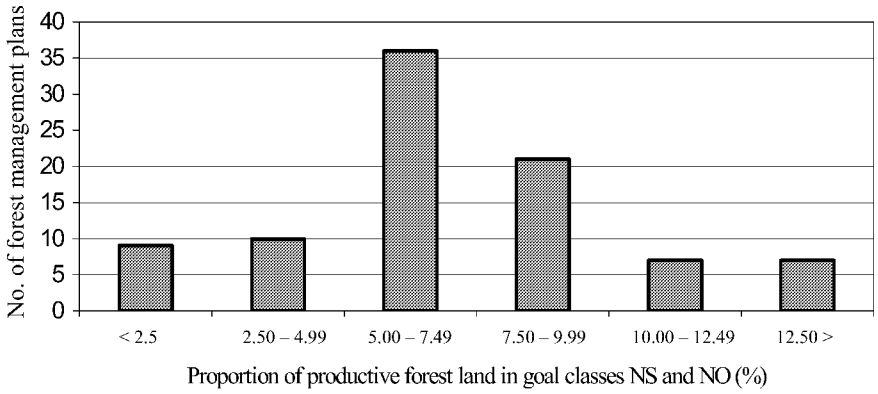

Figure 2. Proportion of forest area in goal classes NS and NO per estate

Nature Conservation on Compartment Level

A regression analysis tested whether the choice of nature conservation areas depends on the estate to which it belongs. No correlation was detected and thereafter all 5223 compartments were analysed irrespective of the estate to which they belonged. Small differences were found between the different agencies producing the plans. Although one organisation had a considerably higher number of plans with a very low percentage set aside, the variation within the organisations was larger than between them. The data collected did not allow statistical analyses on an individual planner level, because the planner was not recorded for every plan.

The stepwise discriminant analysis showed that seven variables have a significant effect, resulting in the classification of NO, NS and P (Table 3). Some variables in the forest management plan are strongly correlated, for example basal area and volume. Either one of them could have been used. In most cases, one of the correlated variables was assessed during the field inventory and the other one was calculated from that value in the office.

Table 3. The importance of different variables for choosing goal classes according to the stepwise discriminant analysis

Variable	Partial R-square	F Value	Significance level
Broad-leaved trees (%)	0.1221	360.86	< 0.0001
Age (years)	0.1014	292.83	< 0.0001
Site Index (m at 100 yr)	0.0401	108.38	< 0.0001
Volume (m^3/ha)	0.0108	28.24	< 0.0001
South/North	0.0093	24.23	< 0.0001
Area (ha)	0.0066	17.21	< 0.0001
Spruce (%)	0.0024	6.36	0.0017

Table 4 defines the discriminant function with the coefficients used to evaluate the probabilities of misclassification in the classification of future goal classes.

Table 4. Estimated linear discriminant function for each goal class

Variable	NO	NS	P
Constant	-50.50	-57.40	-54.16
Area (ha)	0.33	0.40	0.45
Age (yr)	0.25	0.23	0.20
Volume (m^3/ha)	-0.05	-0.05	-0.05
South/North	18.15	18.3	19.15
Broad-leaved trees (%)	0.10	0.15	0.08
Spruce (%)	-0.07	-0.08	-0.08
Site Index (m at 100 yr)	3.16	3.40	3.40

Table 5 reports the differences between the classification according to the linear discriminant model and the classification according to the professional foresters. According to the model the forester misclassified 22% of NS into NO, and 20% of NO was misclassified into NS. Fourteen percent of P was misclassified into NO and 11% of P was misclassified into NS. According to the model 12% of NO and 8% of NS were misclassified into P by the foresters.

Table 5. Forest stands classified into goal classes NO, NS and P, according to the linear discriminant function

True goal class	Goal class classification by linear discriminant analysis			
	NO (%)	NS (%)	P (%)	Total (%)
NO	68.32	19.80	11.88	100.00
NS	22.0	70.00	8.00	100.00
P	14.26	10.76	74.98	100.00
Total	17.95	13.21	68.84	100.00

Figure 3 shows the distribution of six of the seven significant variables. It is clear in Figure 3 (a) that the goal class NS has a considerably higher proportion of broad-leaved trees than the other goal classes and that the median compartment in goal class P contains less than 10% broad-leaved trees. In Figure 3 (b) goal class NO has the highest median value and P has the lowest value. This is also illustrated in Figure 4, which shows the proportion of total areas for the various goal and age classes. NO has a large proportion of the area in older age classes. This trend was not as strong in NS compartments. In goal class P, a high proportion of the compartments were young age classes.

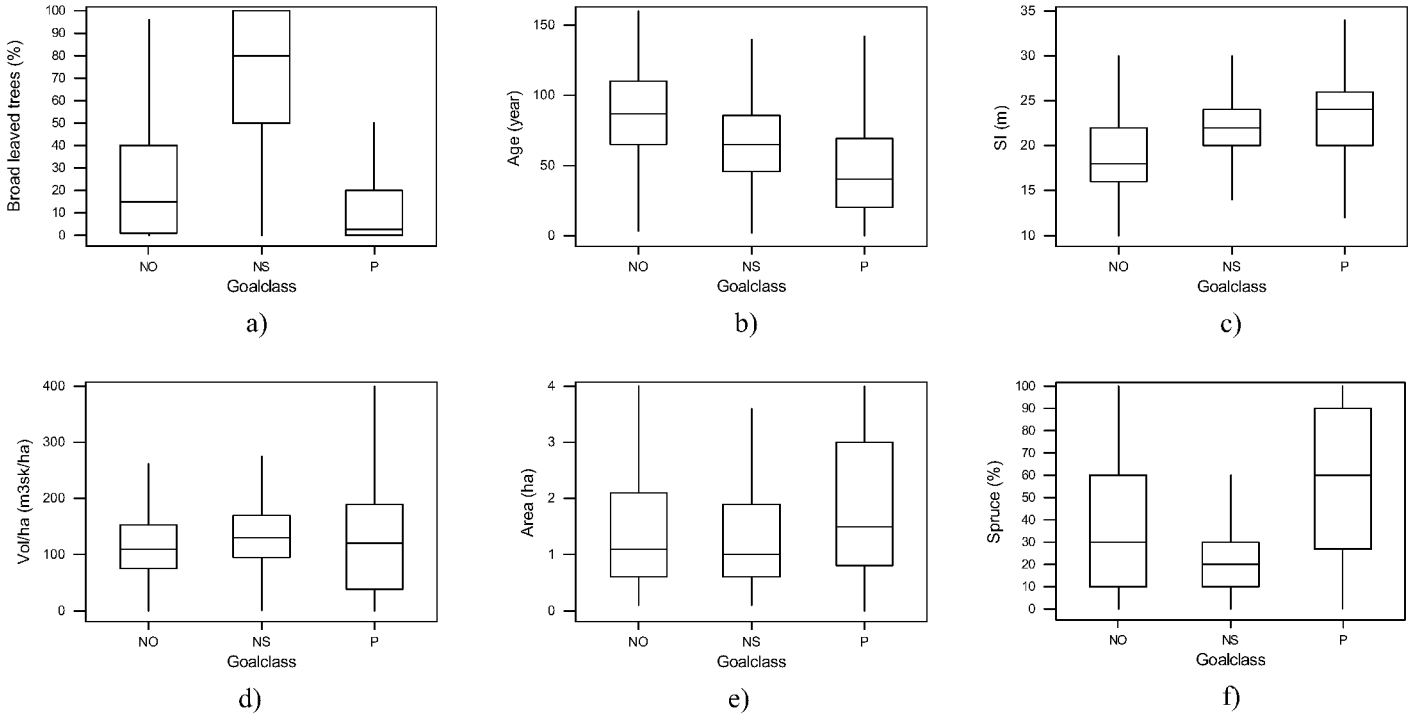

Figure 3. Box-whisker plots of the six variables divided on the goal classes

Note: In a box-whisker plot, the box indicates the first quartile, median and third quartile, while the whiskers indicate the range.

Figure 3 (c) indicates that the site index for goal class P has the highest median and NO the lowest. The volume per hectare has high variation (Figure 3 (d)). The lower quartile shows that production compartments have a high proportion of young stands compared to the other goal classes. Figure 5 provides a better understanding of the sample. For compartments aimed primarily at forest production, the average volume (m^3/ha) increases with increasing age up to the age class 100-119 years. The age class 120+ years is above the normal rotation age: compartments in this age class had not been treated according to normal silvicultural practice or had a low site index. The same trend is seen for compartments for nature conservation with management (NS); however, the trend is not clear regarding compartments that were supposed to be left untouched (NO).

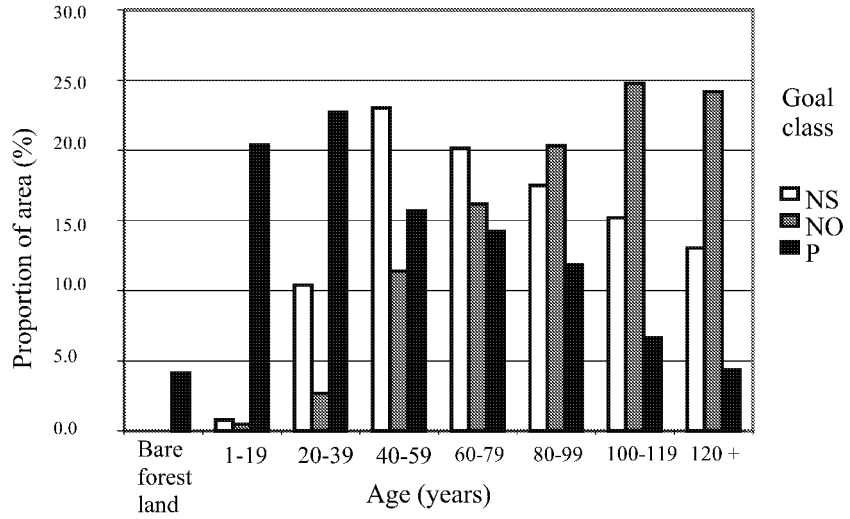

Figure 4. Proportion of total area for each goal and age class

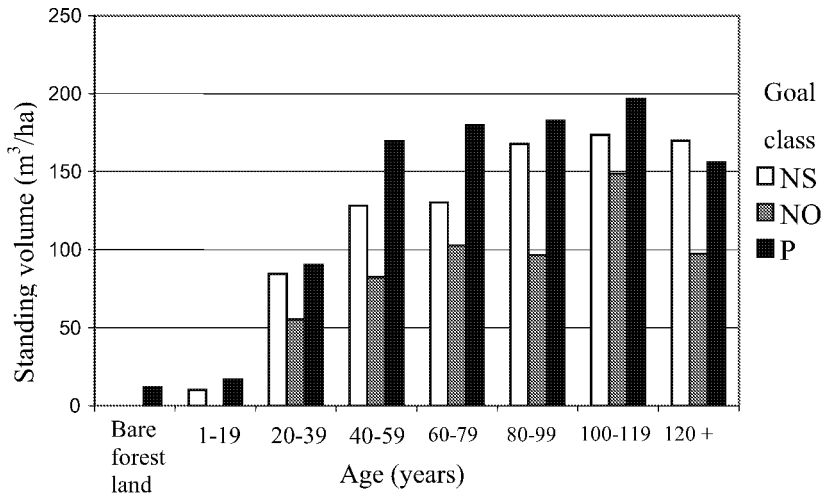

Figure 5. Proportion of average standing volume for each goal and age class

Figure 3 (e) shows the area of compartments for the various goal classes. The difference is smaller between the medians than between the mean values of the goal classes. As indicated here and in Table 6, the average compartment area is smaller for goal classes with nature conservation than for production compartments. Figure 3 (f) shows the percentage for spruce in each goal classes. The value for the median is much higher for P than for the nature conservation classes, and especially NS.

Table 6. Average areas of compartments with nature conservation and production goals

Goal class	No. of compartments	Average compartment area (ha)[a]	Std dev.	Min	Max
NS/NO	520	1.49	1.82	0.1	13.8
P	4703	2.47	3.26	0.1	53.9

a. The mean area for goal class P exceeds that for goal classes NS and NO at the 0.1% significance level.

The dummy variable south/north cannot be depicted in a box plot. For the total proportion set aside in goal classes NS and NO, there is little difference between the parts of the country. However, there is a significant difference between these two goal classes; the proportion reserved for goal class NS is higher in the south and goal class NO dominates in the north (Table 7).

Table 7. Average forest area per management plan, reserved for the goal classes NS and NO in southern and northern Sweden

Goal class	NS (% of area)[a]	NO (% of the area)[b]
Southern Sweden	4.22	3.23
Northern Sweden	0.89	5.23

a. Difference significant at the 0.1% level.
b. Difference significant at the 1% level.

DISCUSSION

The discussion is divided, in the same way as the result section, firstly with the heading policy, instructions and consultations. Thereafter the other sections of the results are discussed with the areas set aside for nature conservation on estate and compartment level.

Policy, Instructions and Consultations

The policy and inventory instructions of the organisations participating in the survey correspond to the National Forestry Boards policy and instructions. All organisations provided education in nature conservation for the professional foresters. However, personal differences occur in the way the forester interprets the instructions for the goal classes.

The organisations clearly describe their policies regarding nature conservation and production goals. The National Board of Forestry produces the clearest and most detailed policy of the organisations studied. All policy documents in the study highlighted the environmental awareness of the organisations in a clear way for both the forest owner and the public. All instructions had similar dispositions and formulations and the goal classifications broadly follow the instruction of the National Board of Forestry.

Contact between the forest inventory staff and the forest owner is a weak point, and differs little between the organisations studied. The differences are greater on an individual level than on an organisational level. The description of nature values, which the organisations have for the compartments with goal classes for nature conservation, is a good foundation for discussions with landowners, and together they could assess the priorities for areas set aside for nature conservation according to the objectives of the forest owner.

Nature Conservation on Estate Level

The percentage of the area reserved for nature conservation corresponds to the percentage of the timber volume reserved; hence, these areas do not seem to be chosen because of low volume. A majority of the plans fulfilled the recommendation stated by the National Board of Forestry, that at least 5% of the productive forest area should be reserved for goal classes NS and NO. However, the recommendation that at least 5% of the productive forest area should be set aside for nature conservation was not always fulfilled. One reason is that existing areas suitable for nature conservation are not always present when the plans are prepared and the possibility for creating such areas was not considered. Another reason is probably that one of the planning organisations in their instructions to the planners only recommended 5% of the property area to be set aside for nature conservation.

Nature Conservation on Compartment Level

The box plots in Figure 3 reveals that goal class NS has a considerably higher proportion of broad-leaved trees than the other goal classes. This was a desired effect from the choice of nature conservation areas. However, the median compartment in goal class P contains less than 10% of broad-leaved trees, which is the recommended minimum stated by the National Board of Forestry. A reason for the high proportion of broad-leaved trees in goal class NS might be that this goal class is predominant in southern Sweden where most of the forest land is culturally influenced with a high proportion of grazing land and marshes with alder trees. Furthermore, the reason for the low proportion of broad-leaved trees in goal class P might be that up to about 1980 broad-leaved trees were considered less valuable and hence were removed in pre-commercial thinning or first thinning.

NS and NO generally have a higher age than compartments with a production goal. This could be due to compartments with older trees being more suited to nature conservation, whereas young forests are primarily established for production purposes, as a result of which most of the young forest areas become production compartments. This effect is desirable for nature conservation. The median of the age variable for the NS compartments is lower than that for NO compartments. One reason could be the high proportion of broad-leaved trees including birch and aspen in NS, resulting in a shorter rotation period.

Compartments in the goal class NO are generally older and have a lower site index than the other goal classes. Compartments with a production goal are generally younger and have a higher site index than compartments for nature conservation. The high proportion of birch and aspen within the NS compartments could be one reason for the lower quartile shown in plot C (Figure 3). The low site index for NO and the high median for NS are desirable effects for the choice of nature conservation areas. Compartments on better sites need frequent maintenance, whereas compartments on poorer sites, mostly conifers, are often left unmanaged in order to create as near to a virgin forest as possible. Goal class NO is more frequent in the northern part of Sweden where it is more common to set aside compartments for nature conservation and free development without any management. This is often the case in old stands situated on land with low site index where the forest has a longer rotation period. That the proportion reserved for goal class NS is higher in the south and goal class NO dominated the north is a desired effect.

The compartments with production goals have a higher proportion of spruce compared to the other goal classes. The median reflects the situation for the whole of Sweden. Generally, forest compartments with the highest production potential have been set aside for forest production. In Swedish conditions, spruce is the most profitable species on highly productive sites. One reason for the low proportion of spruce in goal class NO is that Sweden has two indigenous conifers, Norwegian Spruce and Scots Pine. Pine is less productive on fertile soils but is dominant on poor soils. Furthermore, the expected lifetime of pine is much longer than spruce and the wood is more durable. The low percentage of spruce in the NS compartments (Figure 3c) and the intermediate level of spruce in NO compartments are consistent with the desired effects.

The standing volume in cubic metres per hectare varied between goal classes. One reason is that all age classes, from bare forestland to mature forests, should be represented in a management plan in order to facilitate forestry activities on a sustainable level. The result for the standing volume per hectare for the different goal classes follows the desired effect for nature conservation. The average area of the compartments in goal classes NS and NO is smaller than compartments in the goal class P. This is undesirable for choosing nature conservation areas. One reason for this could be that compartments with production goals need to be of sufficient size and suitable shape for rational management. Another reason might be that areas of interest for nature conservation are often small and were earlier included in production compartments. Some of the compartments set aside for nature conservation are less attractive for harvesting, because of their location and species composition. These areas are often small, but could still have a high volume and site index. Examples of such compartments are stands situated along streams, stands connected to lakes, and swamp areas within the forest. Such types of stands are also less attractive for harvesting, both for environmental and economic reasons.

The average volume per hectare increased with increasing age for all goal classes; however, this trend was not clear for compartments in class NO, possibly due to compartments being situated on poor sites with low standing volumes throughout the rotation period. Many of the compartments in the goal class NO were also considered to be virgin forests with a balance between production of new and dead wood. The total share of area, as well as volume, for classes NS and NO are approximately the same in both southern and northern Sweden, with class NS more

dominant in the south and class NO dominant in the north. NS is more frequent in southern Sweden due to better growing conditions. This is in line with regional classifications (e.g. Ahti *et al.* 1968, Sporrong *et al.* 1995) and recommendations from National Board of Forestry (2001a).

The forest management plan should take the objective of the forest owner into consideration and likewise the plan should give the forest owner the opportunity to take the views of the society into consideration. Therefore, the suggestions of goal classes in the forest management plans are not only dependent on the variables within the plan. Other criteria are involved in decision making by the professional forester, such as the occurrence of endangered species. The areas set aside for nature conservation are recommendations and it is not possible to predict the degree to which these will be followed by the small-scale forest owners.

Three important factors are highlighted by the linear discriminant function. The greatest problem for the analysis was to determine the difference between NS and NO. In many cases it was not evident whether there should be management or not on the area set aside for nature conservation. Some of the production compartments were misclassified into nature conservation compartments. One reason for this might be that there are more compartments suitable for nature conservation than the forest owner wished to set aside. A few nature conservation compartments seem to be misclassified into production. In these cases there could be a lack of suitable compartments for nature conservation.

The statistical treatment of the data was conducted using multivariate data analysis. The authors decided to use discriminant analyses, because three classes needed to be discriminated. Logistic regression analysis is suitable to use for any number of classes, but is mostly used for two classes. Although it may be possible to use logistic regression, it is unclear if this technique is a better choice because discriminant analysis was developed for this type of problem. The green management plans have only been on the market for a few years over the whole of Sweden, thus the results of the linear discriminant analysis could be used for future classification of compartments into classes. It would be interesting to evaluate how the professional foresters will make the classification in the future when they have gained more experience.

CONCLUSIONS

The model was able to discriminate between nature conservation compartments and production compartments. According to the model about 70% of the proposed goal classes, according to the professional foresters, are classified into the correct classes. This indicates that planners mainly use the data in the plan to propose goal classes. There has been a discussion about whether economic considerations affect how nature considerations are set aside. Most of the variables studied showed the desired numbers for the areas set aside for nature conservation, for example age, volume and percentage broad-leaved trees. However, the compartments set aside for nature conservation were generally too small. In the south of Sweden goal class NS dominates, whereas goal class NO dominates in the North. Economic consideration were not found to be the major consideration by the planners for the selection of NS

and NO. However, to be certain that selection of compartments is ecologically correct, further studies, including field tests, are necessary.

The planning organisations studied have adopted the recommendations submitted from the National Board of Forestry. There are clear indications that green forest management plans have complied with the changes in the new national forest policy in Sweden. The national policy seems to be successful. Because the green forest management plans were only recently produced it is too early to analyse the extent to which small-scale forest owners have followed the guidelines laid out in the plans.

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II

Objectives and Motivations of Small-scale Forest Owners; Theoretical Modelling and Qualitative Assessment

Mårten Hugosson and Fredrik Ingemarson

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Forest management changes with societal change, and it has been debated if economic development in society places material objectives in a less preferable position: it is assumed this is also the case as regards forest management. The aims of this study were to propose a theoretical model for empirical studies of objectives and motivations within this field and to depict motivations and objectives of small-scale forest owners in Sweden. Comparative literature studies were undertaken and qualitative methodology was used for the empirical studies. Firstly, to depict general trends among forest owners, interviews with professional foresters were conducted. Secondly, forest owners throughout Sweden were interviewed to compare the results of the interviews with the professional foresters on the motivations and objectives of small-scale forest owners. Within the literature, there were no consistent views on the subjective grounds for owning and managing small-scale forest estates. The proposed theoretical model originated from the cultural concept. Sets of interpretive and normative qualities were seen as underlying people's actions, and such sets were related to basic values. The 'objectives' were clustered into groups creating four clusters i.e. 'motivations'. The four motivations depicted were: Conservation; Utilities; Amenities and Economic Efficiency. The empirical results highlighted that the objectives and motivations of forest-owners covered a broad field and a move towards conservation interests was indicated. The theoretical model presented here is suggested a suitable tool for both depicting the motivations and objectives of forest owners and for making future comparisons.

Keywords small-scale forest owners, professional foresters, forest owners' objectives, forest owners' motivations, forest owners' values, forest management
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1 Introduction

Ideas regarding proper forest management appear to change in conjunction with value-changes in society. Economic development appears to render material objectives less preferable and are gradually replaced by objectives concerning quality of life. Several studies indicate that a change in human values has taken place (Harding et al. 1986, van Raaij 1993, Hakelius 1996, Bengston and Xu, 1997) and it may be assumed that this also affects ideas on forest management. The structure of forest ownership in Sweden is changing. Changes in the law for forming land (1970:988), the government bill (1993/94:27); the committee for residences' report (1993/94: BoU4); the land acquisition law (1979:230), the government bill (1990/91:155) and the committee for agricultures' report (1990/91:JoU26) resulted in deregulation of the property market. The farmer's pre-emptive rights were largely terminated which gave possibility for a new generation of forest owners, with a different set of values, to enter the property market. The changing attitudes were politically manifested as a new Forestry Act (1979:429), the forestry decree (1993:1096), and the Forestry Boards' regulations and general advice (SKSFS 1993:2) passed by the Swedish parliament, became valid in 1994. In the first paragraph (Handbook of... 1994, p. 8) it is stated: 'The forest is a National resource. It shall be managed in such a way as to provide a valuable yield and at the same time preserve biodiversity. Forest management shall also take into account other public interests.' At the same time the regulations of the Act are less detailed leaving decisions largely to the forest owner. One example is the lowering of the minimum age required for final felling. In the context of this paper, an important difference between the two Forest Acts lies in the emphasis on the forest management plan. In the former Act, a forest management plan was required, whereas the Forestry Act of 1994 required only a description of the forest. In order to construct a management plan according to the wishes of the forest owner, data on how owners intend to manage their forest is required i.e. to try to develop the current management plan that parallels traditional aspects and ideas corresponding to the old legislation.

Studies of the internalised driving forces of people can be utilised for increasing awareness of the different types of values and ideas in relation to forest management and enhance the opportunities to manifest personal ideas in the construction of forest management plans and silvicultural systems. Gibbs (1975, p. 19) defines management and silviculture. 'Management is the administrative and regulatory process whereby the policies and objectives established for a forest property are attained ... Silviculture is the process whereby forests are tended, harvested and replaced resulting in a forest of distinctive form'. Silviculture is an integrated part of forest management and the subjective ideational aspects of silvicultural activities are relevant to this study.

The most important qualitative and quantitative studies of forest owner's objectives have been conducted in Finland (Karppinen 1998), Sweden (Lönnstedt and Törnqvist 1990, Lönnstedt 1997) and the US (Kurtz and Lewis 1981, Bliss and Martin 1989). However, no consistent model has been used in these studies and different theories have been applied as a basis for describing the forest owners' objectives. This renders the comparison of different studies difficult. If the objectives concern a particular field of action, in this case silvicultural activities, it could create possibilities for implementing the results within forest management. This is not the case with the models studied during the literature review.

The assessment and representation of subjective qualities such as objectives, and general human values, is a precarious task. To enable consistent depictions allowing comparisons over time, and with regard to different populations, the same concepts and theoretical apparatus for different assessments needs to be applied. Thus, the following is required as regards further studies:

- A consistent theoretical framework enabling depictions and analysis of particular fields of actions
- A conceptual model allowing comparisons between different studies
- Further studies on forest owners' objectives

In Sweden, there is a long forestry tradition among professional foresters. The oldest Higher Education for professional foresters started in 1829 at the Royal College of Forestry in Stockholm and was supervised by chief forest officer Israel Adolph

af Ström (Brynte 2002). The forest industry has been of great importance for both the Swedish economy and employment. Formerly, firewood, charcoal and tar were extracted, whereas today the biggest volume raw material is used for producing pulp. The forest owners in Sweden are usually divided into four groups: Private forests, State-owned forests, community forests and company forests. Some of the private properties are owned by several people. With about 400 000 owners and an average estate size of about 45 hectares, private holdings encompass approximately 50 percent of the total area of forest, or 10.7 millions of hectares (Enström 1997).

Sweden is an useful empirical case as it has a long tradition of forestry and the forest property market changes allowed the possibility of a new generation of small-scale forest (sometimes referred to as non-industrial, smallholder or family forest (Harrison et al. 2002)) owners, with a different set of values, to enter the property market. The aims of this study were firstly, to propose a theoretical model for empirical studies that could allow comparisons with other models and secondly, to use the proposed model for depicting general motivations and objectives of small-scale forest owners in Sweden.

Firstly, a literature review was conducted to study the research within the scientific field. A theoretical model was then constructed and was used during the collection and analysis of the data. Thirdly, empirical data was collected through qualitative interviews with foresters and small-scale forest owners. Finally, a model with motivations and objectives of the small-scale forest owners was presented.

2 Literature Review

The field of enquiry is relatively young in forest science and a majority of the work emanates from the last couple of decades. In this context, the works presented below are salient and important.

Kurtz and Lewis (1981) use a theoretical concept consisting of predefined objectives and motivations to generate a typology of small-scale forest owners. The set of notions is seen as the small-scale forest owners' decision framework and the typology was the result of the application of that framework and a Q-sort testing technique. The two types of subjective ideational qualities ('objectives' and 'motivations') assumed in the theory are causally related and affected by different constraints. The theory states that objectives express 'the end sought' and that motivation represents general 'guiding forces'. Combining a finite set of objectives and motivations, the Q-sorting technique evaluates these combinations with regard to different people's preferences. According to the authors, it is possible to generalise, from sets of subjective evaluations, about typical rationales underlying forest management decisions. These are expressed as four owner types: timber agriculturalist, range pragmatist, timber conservationist and forest environmentalist.

Bliss and Martin (1989) conducted a qualitative study of a group of small-scale forest owners who were particularly interested in forest management. In this work, the notion 'motivation' is chosen in order to represent the driving forces of the chosen group. The notion is not formally defined but from the result, it can be clearly interpreted as a broad category that includes material and social background conditions, as well as general values, for actions relating to forestry. The category includes phenomena such as ethnicity, family, personal identity and forest values. The empirical result of the study indicates that personal identity type of motivations is the most important for the forest manager's actions.

Lönnstedt (1997) compiled a qualitative study presenting goals emerging from forest owners in Sweden. These are divided into five classes: formal economic goals; informal economic goals; production; environmental goals; and intangible goals. Formal economic goals include the categories cash flow, liquidity reserve and capital growth: hunting, firewood and wood for household purposes are included among informal economic goals. Production goals contain different silvicultural methods and aesthetics. Intangible goals include a certain life style. The environmental goals are not discussed. A similar result can also be found in Lönnstedt and Törnqvist (1990), where the emphasis is on forest owners' decision options and the owners' material goal structures are directly considered with no relation

to deeper values.

Conducting a quantitative study, in which a typology created by Pietarinen (1987) is applied, Karppinen (1998) studies the values and management behaviour of small-scale forest owners. Karppinen (2000) refers to (forest-) values and objectives, which may be short and long-term and are seen as equivalent to goals. Objectives are generally portrayed as more concrete than values and 'can be considered as subordinate to values in personal decision hierarchies' (Karppinen 2000, p. 25). Long-term objectives are permanent concepts of desire, which influence behaviour and the results indicate that general (forest) values and long-term objectives of forest ownership are not strongly correlated. Karppinen classified the forest owner into four groups, as originally suggested by Kuuluvainen et al. (1996, p. 303) – 'multi-objective owners; recreationists; self-employed owners; and investors'.

3 Theoretical Modelling

3.1 Driving Forces Underlying Actions

A proper model should reflect the driving forces of small-scale forest owners and be able to reflect and represent traits related to actual silvicultural activities. The model should, secondly, enable representations of general as well as specific driving forces, that is, applied categories and notions should be able to represent traits that would be more stable over time as well as specifically related to present silvicultural practices. Finally, a proper model should also allow other proposed models in the field of forest science to be put into context, that is, it should preferably affiliate to ideas previously proposed. Thereby action-oriented theories would be particularly useful as sources of inspiration.

Theories of action within social sciences are often related to action theory within philosophy. With roots in classical thinking, e.g. Aristotle, the nature, content and metaphysics of action has been examined and discussed, and a classic view of action is represented in the so-called belief and desire (BD-) model (Moya 1990, Mele 1997, Petersson 2000). Briefly, action is related to the beliefs and desires that are 'items' within the subject's mind. These items are 'produced' and 'reproduced' within the mind of the subject as she/he interacts with and interprets different social and physical conditions as a basis for actions in a particular context. The theory is thus causal and dynamic. Firstly, the items created are seen as causing the particular actions performed. Secondly, the items themselves are influenced by the outcomes.

Within contemporary sociology well-expressed models of action are not easily found, perhaps due to the general scepticism towards firm definitions and theorizing instigated by post-modernism in the '80s and '90s. Although influenced by post modernism (e.g. Marcus and Fischer 1986, Tyler 1986), anthropology preserved a basic theory of action (e.g. Kuper 1996) that emanated from the classic anthropologists Kroeber and Kluckhohn. This inspired and influenced the methodology of contemporary social sciences in general (Denzin and Lincoln 2000). A classical theory of culture can be used for depicting particular aspects of social life and particular collectives. Thereby it is applicable for depicting underlying reasons for the management activities of small-scale forest owners.

Culture is thus an aspect of action (Schneider 1976), and within anthropology, practically oriented value-theory is essential to the core concept of culture. Values are ideals of what can be achieved, they are related to the desires of the subject and seen to touch upon the subject's deep emotional as well as intellectual character (Hakelius 1996). According to the classical view of culture, expressed by Kroeber and Kluckhohn (1952), values are seen to guide subjects' interpretation of the 'world' and of normative ideas for actions. From the cultural viewpoint, 'the world' is an arena that consists of ongoing actions, products of actions, and other physical conditions for actions; all these items exist in the real world. 'Under' this arena, i.e. not objectively perceivable cultural traits are created while the subjects perceive, interpret and reflect on this arena. These cultural traits are mental objects that eventually form coherent patterns linked together through the attached, underlying values. With regard to the individual subject, these patterns of traits constitute a kind of a 'mental container', containing

traits at different levels of depths.

Two aspects of the cultivating process can be distinguished: an interpretive and a normative side; 'culture is of and for [action] acquired' (Kroeber and Kluckhohn 1952, p. 181). On the interpretive/'of' side, the subject describes and interprets the picture of the world. On the normative/'for' side, the values guide the creation of norms, which leads to action. In practice, these processes occur more or less simultaneously within subjects, however, the correct causal order may be problematic to establish. The ideal causal direction in the cultural model is through interpretations of norms from which an action is eventually performed. This indicates that interpretation of some kind always precedes actions. The model is fully dynamic in that the eventual actions and the results are thus subject to interpretation.

As a depiction, culture is an attribution to an 'idealised third person' (Werner and Schoepfle 1986). The cultural student 'gathers' traits from a number of subjects with experience of the particular arena and constructs a coherent 'mental container' as an idealized suggestive example. This means that from the point of view of the individual subject he/she can be a carrier of that culture to varying degrees. Important for this conceptualisation of culture is that it is seen as emerging over time. In such a process, the guiding values tend to move away from the awareness of subjects. Thus, values often have to be inferred by the researcher from peoples' explicit interpretations of actions, from norms for particular actions, or from the actions themselves. Furthermore, there is no fixed number of levels between that objective 'surface' and the fundamental underlying values; the deepest level in the container. The number and relative depth of traits in a cultural system is thus left for the student to decide.

To represent culture as such a system, there is a need to define and identify traits on at least three levels: a) ideas concerning concrete actions and conditions for actions; b) ideas concerning types of actions; and c) ideas concerning actions in general terms. In the case of forest management, the first level can be exemplified by specific ideas on soil and water conservation that leads to certain silviculture practices being performed, for example using natural regeneration under shelter instead of clear cutting. The second level would reveal a persistent idea in favour of, as in this example, conservation, and the third level would accordingly reflect general ideas and mental tendencies in favour of a better environment.

3.2 The Proposed Model

The authors proposed that the classical ideas of culture should be utilised in conceptualising the driving forces of small-scale forest owners, particularly on the basis that they are well suited to depict driving forces that concerns particular fields of action; i.e. in this case silvicultural practices. Further, the principal cultural model depicting culture as a system should be used for conceptualisation. In the model presented here, the normative ideas were divided into 'motivations' and 'objectives'. Corresponding interpretive ideas were divided into understandings and descriptions. Values represented the deepest aspect of the model, underlying both normative and interpretive traits.

For studying the driving forces of small-scale forest owners, the motivations and objectives should be primarily considered and depicted. Thus, motivations, being rather general traits, concerned classes of actions; objectives concerned particular types of actions that could actually be performed, such as silvicultural practices. The model considered traits on several concrete levels that reflected subjects' motivations, enabling generalisations of different objectives within a particular group of small-scale forest owners and the classes of actions.

3.3 Discussion about the Proposed Model

It was assumed that the properties sought were rather complex and hard to define and depict. This condition did not necessitate a relaxation of theoretical clarity, rather the opposite. The theoretical proposition originated from classical anthropological ideas and from notions previously used within forest science. The primary reason for choosing the main source was that this approach gave a coherent and systematic depiction of different qualities connected to the process of building normative ideas for actions within groups

of people. In the model proposed, the notions – 'motivations' and 'objectives' for representing the driving forces of small-scale forest owners also affiliated with previously presented ideas (Kurtz and Lewis 1981, Bliss and Martin 1989, Lönnstedt and Törnqvist 1990, Lönnstedt 1997, Karppinen 1998, Karppinen 2000).

As there was a need to depict idealised properties (items) representing driving forces at different levels, a broader more long-term category (motivations), as well as one category that reflected concrete alternatives for actions (objectives), was considered. The term 'goals' (as used by Lönnstedt 1997, Karppinen 2000) was considered as an alternative to 'objectives'; however, within decision making theory, goals represent a state that can be achieved or not (Keeny 1993), whereas objectives were considered as representing tendencies towards a particular state or activity. For depicting driving forces, 'objectives' was perceived as the better choice as these can be realised in actions, even though these actions do not necessarily lead to the fulfilment of particular goals.

For the broader category, the term 'forest-values' (discussed by different authors such as Bengston and Xu 1997, Karppinen 2000) was considered as an alternative to 'motivation'. Karppinen (2000) suggests that forest-values represent values that people hold towards nature and forests in general and do not necessarily concern (potential) actions or conditions on the particular forest-estate of the small-scale forest owner i.e. they are not necessarily applicable to the motivation behind actual activities that are performed. Thus, forest-values were seen as a subordinate to general values and possibly fitting within the second level of the model.

The theoretical model could be seen as a hierarchy of motivations and objectives of varying importance. On a subjective level, each forest owner will have an individual hierarchy of motivations. A theoretical model with distinctively different motivations will not exclude an interweaving of motivations, as forests are always valued in multiple ways, simultaneously (Bengston and Xu 1997). The model proposed by Bliss and Martin (1989) could be argued as an example of this, where the category 'motivations' represents traits from all three levels ('objectives', 'motivations' and fundamental 'values') according to the model presented here.

The model presented here can also be compared to that of Karppinen (2000), as there are many theoretical similarities between them. The 'objective' category of Karppinen, divided into long- and short-term objectives, roughly corresponds to the objectives and motivations according to the conceptualised model presented here. It could also be argued that Karppinen's long-term objectives emphasises deeper aspects than in our 'motivations' category. There also appears to be an unclear distinction between long-term objectives and forest values in Karppinen's model.

The category class of 'goals', as presented by Lönnstedt and Törnqvist (1990), can be seen to correspond to the category of 'motivations' in the proposed model. Different subcategories of these classes of goals can also be seen to correspond to the category objectives. The current authors suggest that specific external factors govern the forest owners' goal-making decisions, which implies that the class 'goals' does not depict ideas that produce actions if other external factors occur. As a result, it can be argued that their category 'goals' is not as deep as the category 'motivations' in the proposed model.

Kurtz and Lewis (1981) present the same notions as presented here although the category 'objectives' is termed 'the end sought'. Both categories of motivations and objectives include rather general traits, not specifying particular management activities and it was considered that their traits, described as motivations and objectives, were equivalent.

4 Empirical Studies

Firstly, professional foresters were interviewed to depict general trends and describe motivations and objectives among small-scale forest owners. The foresters were assumed to express the motivations and objectives through a structured method, because of their cultural background. Secondly, small-scale forest owners were interviewed to compare the results of the interviews with the foresters.

4.1 Qualitative Methodology

A qualitative method was used to explore the motivations and objectives of small-scale forest owners. Qualitative data, with an emphasis on a persons´ experiences, are suited to identifying attitudes towards events, processes and structures in their lives (Miles and Huberman 1994). The method is generally explorative, and the researcher has only preconceived ideas about the topics that should be discussed, thus the interviews are open-ended (Patton 1990, Kvale 1996, Denzin and Lincoln 2000). There has not been a shared tradition of qualitative analytical techniques, but in the past decade, more researchers have shifted towards a qualitative approach (Miles and Huberman 1994).

The qualitative interviews were tape-recorded and lasted on average two hours. They were semi-structured and open-ended, i.e. they followed an interview guide (see Appendices 1 and 2) with proposals on questions. The interviews were allowed to pursue a natural course, but all questions from the initial guide were discussed. At the end of each interview, the researcher verified his understanding of the statements and asked for amendments in accordance with the method used by Kvale (1996).

During the first round of interviews, foresters working on a daily basis with forest owners were interviewed. These informants were chosen primarily for their wide-ranging experience of small-scale forest owners and forest management, which was assumed to indicate that they had reflected upon the objectives and motivations of the forest owners. The informants were asked to describe the small-scale forest owners' management situation of the past, present and future. Different forestry service organisations throughout Sweden were represented. Each organisation, with the exception of the hunting association, could offer private forest owners a forest management plan. The selected informants worked with management services such as felling operations, forest conservation, forest administration, forest management plans, timber trading, forest policy, economic counselling and game management. Fourteen individual interviews with professional foresters were conducted during summer 2000. The professional foresters were men aged between 35 and 61 years. They had 10 to 35 years of experience of working with small-scale forest owners, the majority over 20 years of experience.

Informants ensure that the researcher contacts people, situations and events that contribute to the progress of the research. There can also be a risk if the researcher only relies on what the informants say rather than looking at the world through the eyes of the respondents (the forest owners) (Bryman 2001). Therefore a second round of interviews was performed. The results from the first round of interviews were used as a basis for constructing the questionnaire for the second round of interviews with small-scale forest owners. Eight National Board of Forestry districts throughout Sweden were asked to suggest 32 small-scale forest owners with special interest in conservation, production, amenities, economy or other specialities. This is a general stratification approach for selecting respondents (Bryman 2001). The professional foresters were expected to be well oriented among the local populations of forest owners and have a feeling for 'otherness' as they chose the forest owners. This resulted in sixteen interviews conducted with forest owners during summer 2003. The forest owners were asked to describe their connection to forestry and their activities in the forest and finally, their objectives were discussed. Seven women and nine men were interviewed, with ages ranging between 36 to 65 years. Within the group, there were people with a range of education background from university, college and forestry schools to not having studied in higher education. Three owners received all their income from the forests. Most forest owners worked with planting and cleaning, some with thinning, but very few with final cutting. The forest area varied between 18 to 880 hectares. In most cases, the land was inherited and some had bought their land.

In accordance with the method used by Miles and Huberman (1994), data reduction was used for focusing, sharpening and organizing data that appeared in the transcriptions. Transcriptions were made and the discourse written down. A coding scheme was devised to differentiate and combine the data. Codes are tags used to identify specific themes in a text. The mode of data display was transcribed field notes with attached codes. A list of code definitions was created from analysis

of all the objectives mentioned during the interviews. The codes were clustered, relabelled and revised during the analysis, in accordance with the method used by Miles and Huberman (1994). The method for analysing the data from the informants was the same as for the respondents. The clusters represented motivations and the codes under the motivations represented the objectives of the small-scale forest owners' (see Tables 1 and 2). Finally, the objectives were defined and empirical examples confirming the definitions were chosen from the data.

4.2 Empirical Results

4.2.1 Motivations and Objectives According to the Professional Foresters

During the first round of interviews, the informants were asked to describe forest management that are held by, or are in the process of becoming held by, small-scale forest owners. The following section summarizes the trends among small-scale forest owners in Sweden according to these foresters.

The objectives of forest owners' are changing and the category living on the farm is smaller today compared to twenty years ago. Due to current developments in society, many forest owners have jobs outside the forest business and the traditional forest owner working on their own property will soon be a minority. There used to be a large proportion of self-active forest owners living on the farms combining forestry and farming, but membership in the European Union resulted in a lower agricultural activity among the farmers. Today farm owners strictly performing forestry activities dominate.

According to a professional forester, the value of the property could previously correspond to the return from the forest. Today people are willing to pay for the value of the forest plus for other values. It is believed the interest of the forest has not decreased, rather other interests are considered more highly than previously.

In some districts, the prices of properties are so high that they cannot only be justified by the current timber prices. Because of this, many farmers cannot compete on the property market. There are, for example, successful shareholders and businessmen wishing to invest money in forest properties. One reason could be that owning land might give them possibilities for a better quality of life through activities such as hunting and horses. Another reason might be that money invested in forest properties is not subjected to taxes on capital yield. Further more, it might be an advantage to invest in property before a change of generation. As exemplified by one professional forester: 'The forest has not the same significance as in former days. People appreciate new values. The person buying a property today is of a different type compared to the person that bought land ten years ago. The deregulation of the property market resulted in a change in the structure of the owners. Previously, forest owners bought land to increase the area of their

Table 1. Small-scale forest owners' motivations and objectives according to the informants.

Motivation/Objective	Code	**Motivation**/Objective	Code
Production	P	**Conservation**	C
Timber Production	Pt	Nature Conservation	Cn
Game Production	Pg	Cultural Conservation	Cc
Mushrooms and Berries Production	Pmb	Water Conservation	Cw
Forest Grazing Production	Pf	Soil Conservation	Cs
Amenities	A	**Economical efficiency**	E
Forestry Tradition	At	Yield of Capital	Ec
Challenge of Management	Am	Liquidity Reserve	Er
Aesthetics	Aa	Annual Income	Ei
		Tax Planning	Et

own property. Today people buy a property for horses or hunting. Thereby the forest becomes a side issue and the reason for cutting will not be because of money.'

The professional foresters highlight that the objective is still often economic efficiency, but other values now have to be considered. The interest in natural and cultural values on the property has increased and water conservation is now an important part of the planning for the small-scale forest owner. The professional foresters also emphasized the interest in changing land use, for example to create pastures. Many forest owners feel a strong responsibility for managing the land for previous and future generations. Owning a forest property can also be an irrefutable way of maintaining contact with one's native community.

The motivations and objectives were described and structured according to the information given during the interviews. Four motivations emerged containing 15 abstracted objectives of small-scale forest owners in Sweden (as shown in Table 1).

4.2.2 *Motivations and Objectives According to the Forest Owners*

The results from the first round of interviews were compared with the data set from the second round of interviews. The second interview guides' first part did not correspond to the formula or to the results of the first round of interviews. Still the results from the first round appeared to cover most objectives according to the forest owners themselves. During the second part of the interview, the forest owners were asked to evaluate the results from the first round of interviews. Four motivations emerged containing 16 abstracted objectives of small-scale forest owners in Sweden (as shown in Table 2).

Most objectives and definitions were kept from the results of the first round as they corresponded to the forest owners' opinions. *Challenge of Management* was renamed to *Challenge of Silviculture* as it is more specifically related to the production of timber and was mentioned more often by the forest owners than the professionals. According to the forest owners *Timber production* was associated with the objectives *Challenge of Management* and *Yield of Capital*. Thereby the objective *Timber production* is not found in the results from the second round and the motivation *Production* was renamed to *Utilities*. It was also necessary to divide the objective *Mushrooms and Berries Production*. Firstly, the practices suitable for mushrooms might not be suitable for berries. Secondly, a forest owner could find production of berries important whereas mushrooms may be of no interest. The objective *Emotional Tie* under the motivation *Amenities* differentiated the results of the second round from the first round. Forests are valued in multiple ways (Bengston and Xu 1997) and the following is an empirical example of interweaving of motivations: 'I do not clear cut the best areas for berries, instead I leave a shelter wood of pine. In many of these places I have been collecting berries since I was a little kid.'

Table 2. Small-scale forest owners' motivations and objectives according to the respondents.

Motivation/Objective	Code	**Motivation**/Objective	Code
Utilities	U	**Conservation**	C
Game Production	Ug	Nature Conservation	Cn
Berries Production	Ub	Cultural Conservation	Cc
Mushrooms Production	Um	Water Conservation	Cw
Forest Grazing Production	Uf	Soil Conservation	Cs
Amenities	A	**Economical efficiency**	E
Emotional Tie	Ae	Yield of Capital	Ec
Forestry Tradition	At	Liquidity Reserve	Er
Challenge of Silviculture	As	Annual Income	Ei
Aesthetics	Aa	Tax Planning	Et

Finally, four motivations emerged containing 16 abstracted objectives of small-scale forest owners in Sweden (as shown in Table 2).

The definitions of the objectives and empirical examples confirming them are presented below.

Utilities

The cluster *Utilities* (U) related to producing different products from the forest. It does not include traditional wood production.

Game Management (Ug) represented a will to improve habitats and the amount of forage for game. Examples of management activities were cleaning by cutting the stems at breast height to produce extra forage and limiting the cleanings on clearings. An empirical example: 'I have lots of game and I feel happy with my dense forest. Game management is important and I want my property to be a game preserve.'

Berries Production (Ub) secured the supply of berries in the forest. Some species are favoured by the clear cutting practices, whereas others are favoured by successive felling. An empirical example: 'I will not put any seedlings on a hill with superior cowberries so that the berries will get enough light.'

Mushrooms Production (Um) was one objective as the forest was also utilised by the forest owners harvesting mushrooms. An empirical example: 'to secure the supply of mushrooms, some areas might not be cut, at least under no circumstances become clear felled.'

Forest Grazing (Uf) was concerned with improving the possibilities for livestock grazing in the forest. Pasture could create park-like forests, suitable for recreational areas, for example close to built-up areas. An empirical example: 'I thinned the forest in the large pasture for young animals, to let more light come down through the forest canopy.'

Amenities

The cluster *Amenities* (A) had a close connection to strong underlying values and feelings of pleasantness for forestry. It concerned among other things managing the legacy, intellectual challenge and visual appearance of the forest.

Emotional Tie (Ae) involved the feelings a forest owner develops for special features on a property, a home district or a landscape where he/she has lived. An empirical example: 'During final felling we left a wider edge than usual against the field to lessen the negative emotional effect. My friend and I said farewell to the forest before it was cut.'

Forestry Tradition (At) represented a will to manage the forest for previous and future generations, not leading to a drastic change of the structure of the forest. An empirical example: 'It would be possible to see a bog from the farm, but father did not want us to see it and therefore we have kept that edge dense too keep the tradition.'

Challenge of Silviculture (As) concerned the forest silviculture as a source of intellectual, innovation and physical challenge. One challenge could be to achieve a certain assortment in a compartment. Shelter wood systems were one example of a suitable system for this objective. An empirical example: 'A great satisfaction results from directing, forming and watching how the forest grows.'

The objective *Aesthetics* (Aa) was about the visual appearance of the forest. Examples of aesthetic characteristics were the species, age, density and structure of the stand. An empirical example: 'There is nothing more pleasant than walking in and managing a beautiful forest.'

Conservation

Under the cluster *Conservation* (C), objectives concerning careful management of the forest resources for protective and preserving purposes were gathered.

Nature Conservation (Cn) was a trait that concerned the creation of opportunities for a rich and varied plant and animal life, including biodiversity and forest landscape preservation. Examples of elements favoured were woodland key-elements, valuable hardwood and game trails. An empirical example: 'I promote the conservation of rare species, create suitable conditions for birds and accept damages due to wildlife'.

Cultural Conservation (Cc) represented a will to protect and preserve cultural values. Traces of cultural activities to preserve were for example old roads, croft ruins, milling plants, stonewalls, springs, and also the outward appearance of the landscape. An empirical example: 'Of course it is very important to protect cultural remains, such as stone fences and stone mounds from the Bronze Age'.

Water Conservation (Cw) implied managing water systems in a way that would not destroy the water quality and high conservation values. Water management was achieved, for example, by leaving a curtain of broad leaves along small brooks, or during cutting operations and scarification by limiting the flow of

soil particles into spawning-grounds. An empirical example: 'The salmon trout will not wander up a brook if the water is too warm. In one cleaning I left ten metres on both sides of the river untouched.'

Soil Conservation (Cs) was viewed as protection of the soil from leaching and erosion. It was associated with activities such as the harvesting of biomass for forest fuels, the use of fertilizers, liming, the recycling of ashes, soil scarification, ground damage caused by vehicles, and clear-cut operations. An empirical example: 'I do not like to walk in deep tractor tracks, therefore I write in all felling contracts that all tracks should be covered up.'

Economic Efficiency

Under the cluster *Economic Efficiency* (E), notions reflecting economic objectives for managing forestland were gathered.

The objective *Yield of Capital* (Ec) concerned a high financial return on forest management, including maximizing production. The rate of interest should be high and if the interest in the forest goes below a certain limit, for example 3%, it will be cut. An empirical example: 'The increment might even be negative if the forest is not cut in time.'

If the forest owner saw the forest as a *Liquidity Reserve* (Er), forestry probably did not provide his/her primary main income. The economic output taken from the forest may be used by the farmer, e.g. during years with poor crops, for restoration of buildings or for purchase of equipment. An empirical example: 'So far the forest has been a savings box, which is used for restoration of houses and other buildings.'

Annual Income (Ei) from forest property was an objective reflecting the importance of an even flow of income from the forest property. Annual income was often associated with a high degree of self-activity. The forest capital generated work-income for the forest owner. An empirical example: 'The forest is very important, because it is my livelihood.'

Tax Planning (Et) guided when and what type of management activities should be carried out, depending on the tax system and the structure of the forest. An empirical example: 'Tax planning is important for everyone. I make sure not to pay any taxes without cause, instead I invest the income in the forest.'

4.3 Discussion about the Empirical Results

The empirical model was considered adaptable for practical use because the objectives presented concern actions that could actually be conducted as silvicultural practices. This connection is not apparent as clear in the studies presented in the literature review. The interviews determined there are many objectives influencing forestry activities and the empirical results highlighted that the objectives and motivations of small-scale forest owners covered a broad field, and indicate a move towards conservational interests. Amenities are now an important motivation and should be considered during forest management planning for small-scale forest owners in Sweden. The informants indicated a change in objectives from the 90's onwards; examples included the objectives under the motivation Conservation and Tax planning. Some 'objectives' were similar to those found in Lönnstedt and Törnqvist (1990) and Lönnstedt (1997) (although terminology differs), but more categories emerged in the current study, e.g. Cultural Conservation, Soil Conservation, Water Conservation, Game Production, Forest Grazing Production, Challenge of Silviculture and Tax Planning. The objective Challenge of Silviculture was comparable with the results of Bliss and Martin (1989). The professional foresters interpreted a change among forest owners towards conservation. Lönnstedt and Thörnqvist (1990) assume that ownership of forest properties implies care for them, but there are no direct empirical links to different kinds of conservation as recognized objectives.

Tax planning is important for forest management planning in Sweden, for several reasons. Firstly, high income taxes may be transferred into lower capital interest taxes for the forest owner; secondly, investments in the private forest enterprise may reduce taxes because of favourable tax rules: and thirdly, forest properties are not subjected to taxes on capital yield. The position of owning land was, however, not an objective according to this empirical model, as the objectives should concern particular types of actions that could actually be conducted as silvicultural activities. Neither was recreation an objective as it was considered included in several other objectives of our model e.g. Game Production,

Mushroom and Berry Production, Challenge of Silviculture and Aesthetics.

As legislation limits possible silvicultural activities, and could limit preferred silvicultural activities, it was assumed that foresters and forest owners objectives were influenced by this. For example in areas where reindeer husbandry is active all year round, the private forest owner is obliged to consult with the Sámi (the Lapp population) about suitable silvicultural practices (Handbook of... 1994); however, this land-use pattern is geographically limited to North Sweden.

Certain criticism has been launched against qualitative research due to its lack of precise formulations of methodological approaches. 'The most serious and central difficulty in the use of qualitative data is that methods of analysis are not well formulated' (Miles 1979, p. 591). This old quotation is now only partly true. Several computer software packages are now available for handling the text, storing comprehensive transcriptions and performing a number of analytical operations (Tesch 1990, Miles and Huberman 1994, Weitzman and Miles 1995), but all scientific observations are theory-dependent and fallible (Chalmers 1999).

A selective sample of respondents was chosen. The authors' considered that qualitative research should be 'authentic' and 'explorative', in accordance with e.g. Silverman (1993) and Bryman (2001). Thereby, the particular phenomenon of objectives of forest owners' should be depicted 'deeply' and 'thoroughly'; however, this does not imply that the aim should be for determining how representative a particular objective is or the relative weight of different objectives, which could be the aim of a future quantitative study. However, informants were used and the professional foresters selected the respondents. This could result in some ideas of interest not being depicted.

The foresters' perceptions of forest owners objectives, in comparison to forest owners expressed ideas, indicated that the foresters could express the objectives of the forest owners'. It was reasonable to expect the foresters to be biased by their own values regarding forestry, making them unable to express other normative views. From a cultural point of view, it is reasonable the foresters hold strong and conservative views on how forestry should be performed (Hugosson 1999). However, another important feature of foresters' culture should also be acknowledged, that is a drive for 'correctness' and a 'straight forwardness': this implies the foresters should be very objective, even when it comes to opposing viewpoints. This could also explain why foresters were able to express different objectives. Both these culture traits were indicated by the manner in which interviews with the foresters developed. During the introductory parts of the interviews, the professional foresters' views tended to be limited by the cultural trait, aiming for efficient and effective timber production. However, midway through the interviews, other ideas about the forest owners were expressed, for example amenities. The interviews with the informants also illustrated how the foresters tended to describe the forest owners objectives in well-defined structures, whereas the forest owners themselves often expressed interrelations between objectives and were not as clear in their definitions. This could be interpreted in two ways. On one side, it could be consistent with a culturally related and exaggerated self-reliance when interpreting the forest owners' objectives. Alternatively, it could also be an indication of a true capacity to understand and pertinently express the views of the forest owners.

According to the theory proposed above, there were no absolute definitions of traits. The objectives and motivations presented here were considered interrelated and accordingly suggestive. The motivations that emerged from the study were extracted from the clusters of objectives considered appropriate according to the coding scheme. Empirical examples were chosen from the interviews, however, the relationship between symbols and meanings could have a private character. Hence, the particular expressions of the interviews could be assumed to represent slightly different phenomena (Wagner 1986, Simonsen 1997). A subject's discourse as a direct route to 'inner-experiences' is also regarded as problematic as there may be a reason for the subject to refer to ideal states rather than to actual experiences (Silverman 1989). These interpretations are also intrinsically linked to the presumptions that the interpreter brings to the interpretive context.

Within the literature, there are no consistent views on the subjective grounds for owning and

managing small-scale forest estates. The theoretical model presented here could be considered a suitable tool for depicting both the motivations and objectives of forest owners and for making comparisons with forthcoming work. Although the empirical results are currently limited to Sweden, the general theoretical assessments and clarifications may already have broader applications for the forestry sector in general. The study showed that small-scale forest owners could have many different objectives that affect silvicultural practices in different ways. Future work could focus on evaluating different practices' adaptability to these objectives. In time, the model presented here could prove a useful tool for predicting changes in small-scale forest owners' objectives and motivations for forest management.

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Appendix 1. The interview guide for the professional foresters.

1. How does your organisation construct a forest management plan?
2. What objectives do you think the forest owner has for his/her forest management?
3. Which objectives do you think the forest owner considers the most important today (place in order of precedence)?
4. How has the management situation changed for the small-scale forest owners' while considering past, present and future?
5. a. For what do you think the forest owner uses the forest?
   b. For what do you think the forest owner *would like* to use the forest?
6. Which different 'types' of forest owners do you have contact with?
7. Are you actively trying to find out what objectives the forest owners have?
8. What are the most common reasons that a conflict between forest owners' objectives arises?
9. If you were a forest owner, how would you plan when it comes to the objectives and the field of applications?
10. How should a forest management plan be developed to meet these objectives and field of applications?
11. Is the forest management plan constructed by your organisation adjusted to these objectives and field of applications?

Appendix 2. The interview guide for the small-scale forest owners.

1. Describe the history of your selves, your family and the connection to forestry?
2. Describe the history of the property?
3. Which objectives do you think are the most important today (place in order of precedence)?
4. How is the structure of your forest today (discuss about the data in the forest management plan)?
5. How would you like to have the structure of the forest in the future?
6. a. Why do you own forest?
   b. For what purpose do you use the forest/what are you doing while you are in the forest?
7. Do you have any objectives/directions as a forest owner?
8. a. Do you believe these objectives (table 2) are useful for describing your situation as forest owner (the forest owner comments each objective and relate it to his own situation)?
   b. Is there anything missing in the picture (table 2) described above?
9. a. What do you think about the forest management plan?
   b. Does the management plan reflects your objectives?
10. a. Tell about your contact with professional foresters?
    b. Do you believe the professional forester can describe the situation of the forest owners and the need of his/her forest management?

III

A typology of small-scale private forest owners in Sweden

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Abstract

Planning instruments, for example forest management plans, have to be consistent with the underlying values of the forest owners' to have an influence on their management activities. Several studies have indicated that human values are shifting, and it can be assumed that the changes will affect ideas on forest management. The production of timber sometimes has little, often negligible, significance for the finances of the small-scale owners' households in Sweden, but the forest can still be of great strategic significance for their way of life. The aims of the present study were to identify different types of forest owners, to quantify their objectives and to validate a previous, qualitative study of the objectives of the small-scale forest owners. A survey was conducted and forest owners were classified by means of cluster analysis into five types: 'the economist', 'the conservationist', 'the traditionalist', 'the optimist' and finally 'the pessimist'. Significant factors characterising these owners are presented and discussed. The results showed that clear sub groups of forest owners can be differentiated by their objectives and confirm recent studies suggesting that a sole emphasis on economic benefits is not desirable from the forest owners' point of view. The findings should give a better understanding of the behaviour of the small-scale forest owners and provide a basis for further research, counselling and development of forest policy.

Key words: amenities, conservation, economic efficiency, forest owners' goals, forest owners' motivations, forest owners' objectives, forest owners' values, forest policy, utilities.

Introduction

Understanding the objectives of forest owners is important for the success of policy initiatives, for promoting successful sustainable forest management (Bliss & Martin 1990) and for adapting extension services to the varying motivations of the forest owners (Kurtz & Lewis 1981, Karppinen 1998a). Planning instruments, for example forest management plans, have to be consistent with the underlying values of the forest owners' to have an influence on their management activities (Ingemarson *et al.* 2004).

Background

Several studies have indicated that human values are shifting (van Raaij 1993, Hakelius 1996, Bengston & Xu 1997 *a.o.*), and it can be assumed that the changes will affect ideas on forest management (Hugosson & Ingemarson 2004). Forests in Sweden are usually divided into four groups according to the status of the owners: private forests, state-owned forests, community forests and company forests. Forty percent of private forest acreage has more than one owner. With about 350 000 owners and an average acreage of about 45 hectares productive forest, private holdings encompass approximately 50 percent of the total area of productive forest in the country, or 11.4 million hectares (National Board of Forestry 2003). In the South, properties are smaller, with greater biological diversity and productivity compared to those in the north of Sweden. Most small-scale forest owners, sometimes referred to as non-industrial, smallholder or family forest owners (Harrison *et al.* 2002), live in the South and control 57% of the timber production in the country. At the same time, the production of timber has little, often negligible, significance for the economy of the owners' households. In spite of this, the forest can still be of great strategic significance for their way of life. Thus, the perspectives of researchers and policymakers concerned with issues related to forest owners must be widened to consider aspects of their attitudes and behaviour beyond their role as suppliers of timber (Törnqvist 1995). Bengston & Xu (1997) point out that forest values cannot be reduced to a single dimension, the values are multidimensional. Karppinen (1998a) suggests that a sole emphasis on economic benefits does not lead to active silviculture and harvesting behaviour. In Sweden, the trends indicate that: increasing proportions of small-scale forest owners are living outside their property (Lidestav & Nordfjell 2002); the numbers of farming owners are decreasing (Eriksson 1989a, Törnqvist 1995, National Board of Forestry 2003); larger proportions of forest properties are being shared by groups of owners (Lidestav & Nordfjell 2002, Mattson *et al.* 2004); and the proportion of female owners is increasing (Lidestav & Ekström 2000).

Swedish forestry provides interesting cases for empirical studies, since it has a long tradition. Changes in the forest property market in the early 90's allowed a new generation of small-scale forest owners, with a different set of values, to enter the property market (Hugosson & Ingemarson 2004). A change in human values was politically manifested when a new Forestry Act came into force in 1994. In the first paragraph it states (National Board of Forestry 1994, p.8): "The forest is a National resource. It shall be managed in such a way as to provide a valuable yield and at the same time preserve biodiversity. Forest management shall also take into account other public interests." At the same time, some provisions of the Act are less detailed than corresponding provisions in the preceding legislation, thus, leaving decisions largely to the forest owner. In the former Act a forest management plan was required, whereas in the 1994 Forestry Act only a description of the forest is required. The proposed silvicultural practices should be suitable for the objectives of the forest owners. In order to construct a management plan according to the wishes of the forest owner, information on how people intend to manage their forest is required. This can be done by studying the relationship between owners' objectives and their social and economic characteristics.

A qualitative study by Hugosson & Ingemarson (2004) presents a model describing the broad range, structure and characteristics of motivations and objectives of the forest owners related to silvicultural activities (Table 1). The present study is a quantitative follow-up of the previous qualitative study.

Table 1. The structure of small-scale forest owners' objectives, according to the professional foresters (Hugosson and Ingemarson 2004)

Motivation/Objective	**Code**	**Motivation**/Objective	**Code**
Production	**P**	**Conservation**	**C**
Timber Production	Pt	Nature Conservation	Cn
Game Production	Pg	Cultural Conservation	Cc
Mushrooms and Berries Production	Pmb	Water Conservation	Cw
Forest Grazing Production	Pf	Soil Conservation	Cs
Amenities	**A**	**Economical efficiency**	**E**
Forestry Tradition	At	Yield of Capital	Ec
Challenge of Management	Am	Liquidity reserve	Er
Aesthetics	Aa	Annual Income	Ei
		Tax Planning	Et

Aims

The aims of this study were to identify different types of forest owners and quantify their objectives. If the model presented by Hugosson & Ingemarson (2004) is valid, it should be possible to create a typology of forest owners built upon these ideas. The results should give a better understanding of the behaviour patterns of the private forest owners in different situations and should provide a useful basis for further research, counselling and the development of forest policy.
The following examples illustrate the type of questions raised:

- Are conservation-oriented forest owners young city-dwellers?
- Are forestry traditions most important to owners who acquired their holdings from the family?
- Do forest owners who emphasize economic objectives own large estates and have a high level of education?

Literature review

Several studies have examined various issues related to small-scale forest owners over recent decades in Sweden. These issues include: the differentiation of the forest owners (Eriksson 1989a, b, Löfgren 1989a, b, c, Lönnstedt 1989, Wallner 1989, Carlén 1990, Sennblad 1990, Dahlin & Eriksson 1992, Törnqvist 1995, Lidestav & Ekström 2000, Hugosson & Ingemarson 2003, 2004, Mattsson *et al.* 2004); harvesting behaviour (Drakenberg & Höök 1975, Drakenberg *et al.* 1978, Carlén 1986, Carlén & Löfgren 1986, Lönnstedt 1986, Sennblad 1988a, b, 1996); decision models (Hansson *et al.* 1990, Lönnstedt & Törnqvist 1990,

Lönnstedt 1997); subsidies (Hultkrantz 1986, Provincial Forestry Boards 1986, Swedish National Audit Office 1986); information and counselling (Roos & Törnqvist 1991, Eliasson 1993, Westergren 1994, Sennblad 1998, Ingemarson & Hedman 2001, Ingemarson *et al.* 2004); and taxes (Löfgren 1992, Håkansson 2002). Outside Sweden, the following studies of forest owner's objectives are among the most important: for Denmark, Boon *et al.* (2004); for Finland, Pietarinen (1987), Kuuluvainen *et al.* (1996), Ripatti & Järveläinen (1997), and Karppinen (1998b); and for the US, Kurtz & Lewis (1981), Marty *et al.* (1988), Bliss & Martin (1989) and Kline *et al.* (2000).

Values and objectives are dependent upon the cultural, institutional, social and economic environment in the respective country. This complicates comparisons between countries, but studies of typologies comparable to the present study have been undertaken outside Sweden. Typologies of forest owners' are mostly based on empirical evidence, in the form of qualitative (Kurtz & Lewis 1981, Hugosson & Ingemarson 2004) or quantitative data (Karppinen 1998a, 1998b, Pregernig 2001, Boon *et al.* 2004). Forest owner typology studies are mostly based on ownership objectives. The main factors separating owners in different countries have been studied by Boon *et al.* (2004). The comparisons show that the owners tend to fall within the following five types: 'the economist', 'the multiple owner', 'the recreationist', 'the self-employed' and finally 'the passive owner'. This is similar to the typology presented by Kline *et al.* (2000), describing four types of owner; 'the timber producer', 'the multi-objective owner', 'the recreationist', and finally 'the passive owner'. Kurtz & Lewis (1981) used a theoretical concept consisting of predefined objectives and motivations to generate a typology of small-scale forest owners. The typology recognises four owner types: 'the timber agriculturalist', 'range pragmatist', 'timber conservationist' and 'forest environmentalist'. Karppinen (1998b) studied the values and management behaviour of small-scale forest owners, in which a typology created by Pietarinen (1987) was applied. Karppinen classified the forest owners into four groups, as originally suggested by Kuuluvainen *et al.* (1996): 'multi-objective owners', 'recreationists', 'self-employed owners', and 'investors'. Boon *et al.* (2004) presented an empirically-based typology of three clusters: 'the classic forest owner', 'the hobby owner' and 'the indifferent farmer'.

Material and methods

In accordance with Dillman (1991), the following four sources of error were considered during the planning of the survey: sampling error, non-coverage error, measurement error and non-response error.

The sample

A nation-wide survey of small-scale private forest owners in Sweden was conducted during 2003. Statistics Sweden (SCB) collected the survey data by mail questionnaires. The population consisted of all private forest properties with forest

holdings of between 5 and 8000 hectares according to the Swedish forest data register, originating from the property taxation register. The Swedish forest data register lists all members of the population of forest properties, giving known probabilities of sampling any property. This should not lead to any non-coverage error. The random sample was stratified into four strata according to the properties' forest acreage. The probability of selection increased with the size of the forest property, resulting in an overrepresentation of large forest properties compared to the population as a whole (Table 2).

Table 2. The composition of the sample

Stratum (size)	Total distribution (N)	Sample (No.)	Sample proportion (%)	Respondents (No.)	Response rate (%)
5 - 24 ha	86474	333	0.39	193	58.0
25 - 99 ha	81370	906	1.11	559	61.7
100 - 399 ha	25395	625	2.46	366	58.6
≥400 ha	1880	158	8.40	81	51.3
Total	195119	2022	1.04	1199	59.3

A questionnaire was sent at the beginning of March to the owners of the 2022 selected forest properties, and a reminder letter was sent at the end of the month to 1412 non-respondents. If the forest property had several owners, the questionnaire was sent to the contact person, which every property in Sweden must have by law. The 1147 owners who had not responded by the beginning of April received a second reminder and a new questionnaire. A telephone follow-up call was made to a sample of 250 of the 889 non-respondents, resulting in a further 126 answers. After two postal reminders and the telephone calls the response rate stood at 59.3%. The internal none-response for questions concerning the forest owners' objectives was about 10%, and resulted in 1010 complete answers.

The non-responses

Some of the forest owners of the sample population did not answer the questionnaire, possibly causing non-response errors. A high response rate may help to eliminate non-response bias. Low response rates have been considered the main problem of mail surveys. However, procedures are available to assure response rates of at least 50% for most populations, according to Dillman (1991). The response rate of the present study, 59.3%, should thus be regarded as satisfactory. The questionnaire was comprehensive, but according to Kanuk & Berenson (1975), the evidence gives little support to the view that shorter questionnaires result in higher response rates. Still it cannot be eliminated that long questionnaires can be repulsive to some respondents. The questionnaire used in this study was cut to lessen the risk of none-response.

Negative attitudes towards the survey research industry may also inhibit responses (Martin 1994). In the present study, government and university sponsorship was involved, which according to Kanuk & Berenson (1975) has significant advantages over commercial sponsorship.

The groups of respondents and non-respondents were compared to assess the statistical significance of differences between them. The analysis showed no significance at the 0.05 probability level for the following variables; stratum 5-24 ha, stratum 100-399 ha, region North, region South, region population centre, distance to residence, living in the municipality, living outside the municipality, living outside the county and age. For strata 25-99 and strata ≥400 ha, there were significant differences. Since the stratification was area-based, this potential source of bias was not considered a problem. A test of the hypothesis H_0: $p_R = p_{NR}$ showed that the proportion of women amongst the non-respondents deviated from the mean results at the 0.01 probability level (see Table 3). Even though the differences mentioned are statistically significant, they are relatively minor in absolute terms and can be considered to have limited effects on the overall results of this study.

Table 3. Numbers of responses and non-responses for the sample of women

	Response (R)	**Non-response (NR)**
Total sample (No.)	1199	823
Women (No.)	215	218
Proportion women (p)	0.18	0.28

The Questionnaire

The questionnaires included 25 questions concerning the forest owners' background, characteristics of their estates, forest management activities and the importance of their objectives. The management activities are not discussed in this article. The respondents were asked to assess the importance of the 15 objectives of forest owners, according to the professional foresters surveyed by Hugosson and Ingemarson (2004), on a five-point scale (Figure 1). Before each question, the meaning of the objectives was explained to the respondents in accordance with the definitions by the cited authors. The forest owners were also asked to predict the importance of each objective five years in the future.

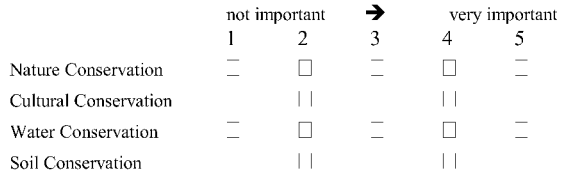

Figure 1. Answering alternatives about the importance of objectives related to the motivation 'conservation'.

The following features were considered to improve the response rate, in accordance with Kanuk & Berenson (1975), Dillman (1991) & Martin (1994): questionnaire layout, source of survey sponsorship, content and personalization of

cover letter, type of return postage, anonymity of the respondents, follow-up reminders and timing of follow-ups.

Statistical methods

Clustering of observations is used to classify observations into groups when the groups are not initially known. Different agglomerative hierarchical clustering procedures were tested using the MINITAB software package (MINITAB 13:20 (2000)). A hierarchical classification does not partition the data into a particular number of classes in a single step. Initially, all observations are separated and during the first step, the two closest observations are combined. The process continues until all clusters are joined into a single cluster containing all individuals. The final partition of clusters should share common characteristics. The pattern of changes in the similarity or distance values from step to step determines the final cluster grouping. Different linkage methods determine how the distance between pairs of clusters is defined.

The objectives of the owners' were grouped, by means of cluster analysis, according to their similarity in level of importance as stated by the respondents. Different linkage methods were tested, such as 'single linkage', 'average linkage' and 'Ward's linkage'. In addition, the statements about the 15 objectives were compared in pairs to study the differences identified in the cluster analyses.

To establish a typology of forest owners, cluster analysis was used to group the respondents based on their stated views of the importance of the objectives. It was desirable to have a similar number of observations in the different clusters and for the groups to be mutually excluded rather than overlapping. The objective of Ward's linkage method is to minimise the within-cluster sum of squares, often resulting in clusters with similar numbers of observations. Other methods were also tested, but the characteristics of the observations appeared to work best with Ward's linkage method. It is sensitive to outliers, but the five-point scale did not produce any. Ward's linkage method has also been used by Pregernig (2001) and Boon *et al.* (2004) for determining typologies. After testing various numbers of clusters, it was found that five different clusters resulted in the most suitable typology of forest owners in Sweden.

Analyses of variance were performed on owners and forest characteristics to validate the results of the cluster analysis and to facilitate comparisons with other studies. The mean values were treated as large independent samples and z-tests were performed on both the mean values and the proportions to test the statistical significance of differences. If the variable consisted of more than two categories, for example the size of the property, a Chi-square test was used. Then the non-independence was tested in a two-way classification to find out if the classification of one variable depended upon the classification of the other variable. Five columns (clusters) were included for each variable in the tests, resulting in multiple two-way tables. For each table a chi-square test was performed. Analyses of variances were performed on the following variables: productive forest area; sex; respondents residence; distance from estate to residence; region; age; duration of

ownership; acquisition from within the family; grew up in the countryside; respondents attendance rate at the estate; knowledge index; hunting; expected take-over; income from the forest; a forest management plan; no change of land use; interest in buying land; direct heir; education level; and land set aside. The important variables are presented in Table 4.

Results

The clusters of objectives

The forest owners were asked in the questionnaire to comment if any objectives were missing from the results of the previous qualitative study. This did not reveal any traits that were not mentioned in the earlier study by Hugosson & Ingemarson (2004).

The results of the cluster analysis of the forest owners' objectives were similar, irrespective of the chosen linkage method. A dendrogram of the results with the 'single linkage' method is presented in Figure 2. The qualitative model for the different groups of objectives, presented in Table 1, was consistent with the proposed clusters identified in the cluster analysis, except for the group 'production'. The objectives 'timber production' and 'forest grazing' divided this group. The 'conservation' cluster was homogenous, as was the 'amenities' cluster.

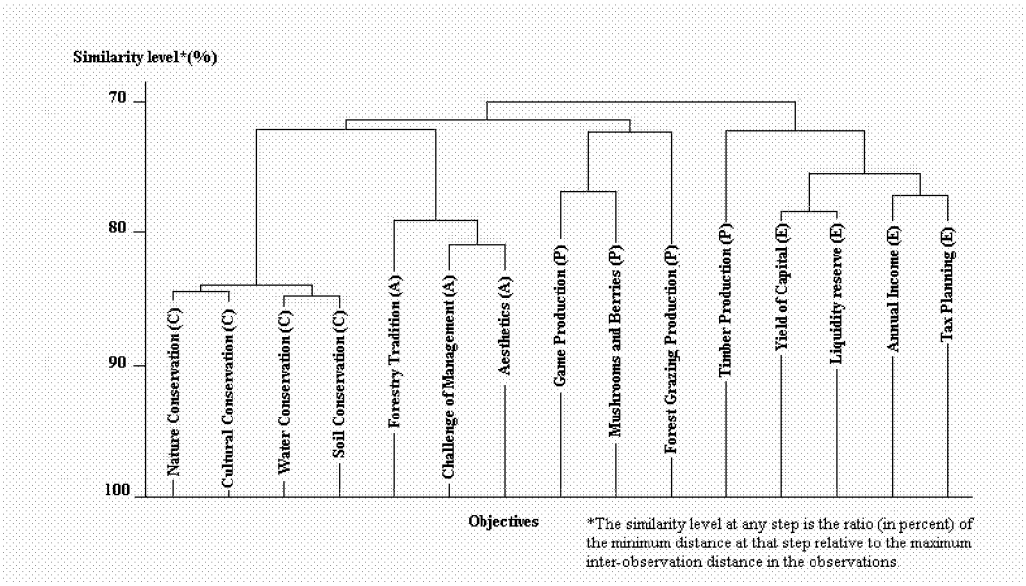

Figure 2. Results of the cluster analysis of the forest owners' objectives.

The comparison in pairs confirmed the results of the cluster analysis, for example, it showed that about 70 percent of the respondents gave the same statements about the four 'conservation' objectives and the similarities between 'timber production' and the other 'production' objectives were small.

The clusters of forest owners

The five clusters of forest owners were named according to how they ranked the different objectives (Figure 3). The cluster analysis model placed most forest owners (308) in 'the economists' group. The cluster of 'traditionalists' included 208 forest owners. 'The optimists' formed the smallest cluster with 129 forest owners, whereas 'the conservationists' and 'the pessimists' included 174 and 191 owners, respectively. Most forest owners found 'timber production' important and 'forest grazing' unimportant, so these objectives had little influence on the call of the clusters. 'The economists' gave 'economic efficiency' the highest scores. 'The conservationists' were not motivated by financial concerns, but gave all 'the conservation' objectives high scores. 'The traditionalist' curve seemed to follow the mean curve of the five clusters, except for 'amenities', including the objective 'forestry tradition'. 'The optimists' and 'the pessimists' were the least differentiated clusters. 'The optimists' found all objectives important, whereas 'the pessimists' gave lower ranking than the other clusters to all of the objectives.

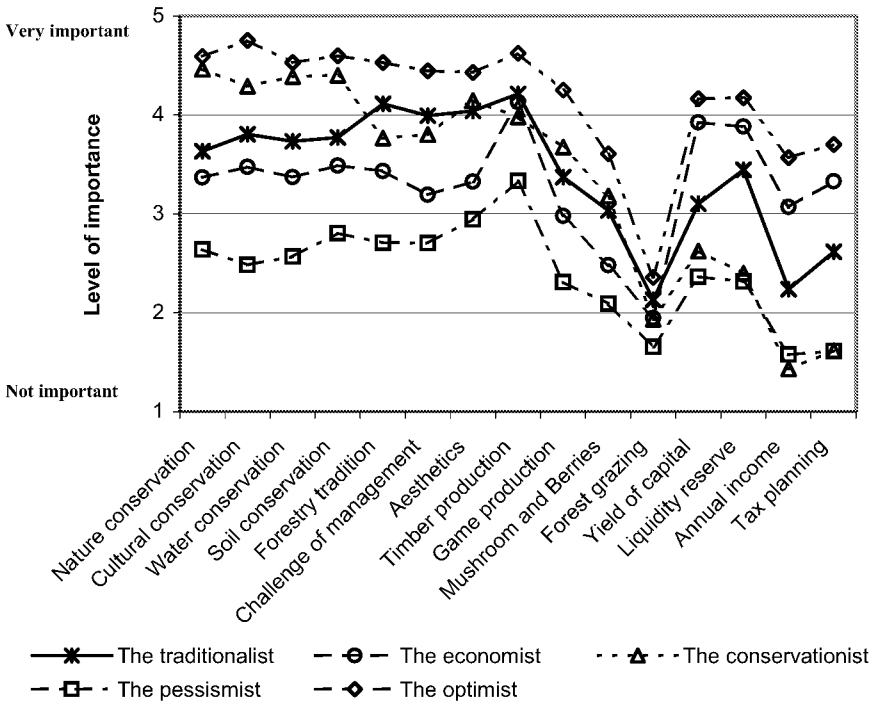

Figure 3. Results from the cluster analysis of the forest owners according to their stated views of the level of importance of the objectives.

Characteristics of the clusters

Cluster 1 – 'The traditionalist'

'The traditionalists' seemed to follow the mean value of all clusters of forest owners (Table 4). Most had an estate with forest acreage of 25 to 99 hectares and lived in the municipality of the estate (Table 5). On average, they were about 57 years old, the duration of ownership was slightly more than 20 years and more than 80% had acquired their holdings from the family. About half of the group lived on their respective estates, and the distance between their residence and their forest was on average barely 60 km. Most of 'the traditionalists' expected their children to take over their estates, and more than 10% of their income came from the forest for slightly more than a quarter of them. Slightly less than 40% of 'the traditionalists' had a forest management plan no older than ten years and a somewhat higher proportion would consider buying more land. 'The traditionalists' share characteristics with 'the forest environmentalist' according to Kurtz and Lewis (1981), and some characteristics with 'the hobby owner' according to Boon *et al.* (2004).

Table 4. Mean values of significant owner characteristics of the clusters

Characteristics	**Tradition.**	**Econom.**	**Conserv.**	**Pessimist**	**Optimist**	**All obs.**
No. of respondents	208	308	174	191	129	1010
Sex, women (%)	18.8^{b}	18.0^{b}	21.4^{b}	18.9^{b}	8.5^{a}	17.7
Age (years)	56.6^{b}	54.7^{a}	55.0^{a}	57.4^{c}	56.7^{bc}	55.9
Duration of ownership (years)	21.1^{b}	22.3^{c}	17.5^{a}	20.6^{b}	26.2^{d}	22.5
Acquisition from within the family (%)	83.6^{b}	91.1^{c}	72.3^{a}	82.5^{b}	86.6^{bc}	84.1
Distance from estate to residence (km)	56.5^{c}	49.9^{b}	79.3^{e}	65.4^{d}	21.7^{a}	55.9
Grew up in the countryside (%)	84.5^{b}	89.3^{b}	74.7^{a}	86.2^{b}	90.6^{b}	85.3
Knowledge index[y] (0-4)	1.83^{b}	1.77^{b}	1.65^{b}	1.33^{a}	1.95^{c}	1.65
Forest Management plan, ≤10 yr (%)	37.0^{a}	47.7^{b}	37.4^{a}	33.5^{a}	37.2^{a}	39.7
No change of land use[z] (%)	84.1^{a}	85.7^{ab}	86.8^{abc}	92.1^{cd}	82.2^{ac}	86.3

[abcde] Observations with no superscript letter in common are significantly different at the 0.05 probability level according to a z-test. Region, hunting, direct heir and land set aside did not significantly differ amongst the five clusters.

[y)] Knowledge index was calculated as the sum of the following sources of forestry knowledge stated by the respondents, 'Practical experience', 'Forestry journals and literature', 'Short courses and information meetings' and 'Forest education extending one year or more'.

[z)] The answering alternatives to 'No change of land use' were active change from '… agricultural land to forest', ' … forest to agricultural land', '… timber to game production', '… timber production to nature conservation' and 'other change of land use'.

Cluster 2 – 'The economist'

'The economists' lived on large estates and were relatively young. Most of them had grown up in the countryside, they had acquired their holdings from the family and they could consider, to a high degree, options other than letting their children take over their estates. The incomes from the forest were large, and half 'the economists' had a forest management plan. 'The economists' knowledge index, educational level and interest in buying more land were intermediate. 'The economist' is similar to 'the investor' of Karppinen (1998b), 'the timber producer' according to Kline *et al.* (2000) and shares some characteristics with 'the classic forest owner' according to Boon *et al.* (2004).

Cluster 3 – 'The conservationist'

'The conservationists' owned small estates, there was a large distance between their forest and their residence and the forest provided a very low proportion of their income. They were also somewhat younger, had owned the land for a relatively short time, and a small proportion of them had acquired their holdings from their families. A significantly larger proportion of 'the conservationists', compared to the other clusters, had grown up in a city. 'The conservationists' knowledge index and educational level were intermediate. This group had little interest in buying more land. 'The conservationist' is comparable with 'the timber conservationist' according to Kurtz & Lewis (1981), 'the recreationist' by Karppinen (1998b), Kline *et al.* (2000) and 'the hobby owner' according to Boon *et al.* (2004).

Cluster 4 – 'The pessimist'

'The pessimists' owned small estates, were older and a large proportion of them visited their estates less than 10 times per year. They expected their relatives to take over their estates to a lower degree than the other clusters. Few of 'the pessimists' had a forest management plan, and the forest rarely supplied more than 10% of their income. They also showed the least inclination to change the direction of land use, little interest in buying land and the lowest knowledge index. 'The pessimist' is similar to 'the passive owner' according to Kline *et al.* (2000) and 'the indifferent farmer' according to Boon *et al.* (2004).

Cluster 5 – 'The optimist'

'The optimists' lived on large estates with a long duration of ownership and expected their children to take over. They had grown up on the countryside, a large proportion of their income came from the forest and they were most interested in buying land. A change of direction was noted to a larger degree among 'the optimists' compared to the other clusters. The level of education seemed to be low, but on the other hand, they had a higher knowledge index than any of the other clusters. 'The optimists' also had the lowest percentage of women of the five clusters. 'The optimists' share many characteristics with 'the timber agriculturalist' according to Kurtz & Lewis (1981), 'the multi-objective owner' according to Karppinen (1998b) and Kline *et al.* (2000), and 'the classic owner' according to Boon *et al.* (2004).

Table 5. Distribution of significant characteristics of the clusters

Characteristics	Tradition.	Econom.	Conserv.	Pessimist	Optimist	All obs.
No. of respondents	208	308	174	191	129	1010
Productive forest area (%)* **						
5-24 ha	14.4	4.2	26.4	23.0	4.7	13.8
25-99 ha	45.2	42.9	47.7	52.4	32.6	44.7
100-399 ha	30.8	39.6	23.0	19.9	54.3	33.1
≥400 ha	9.6	13.3	2.9	4.7	8.5	8.5
Respondents residence (%)*						
In the same municipality	66.3	61.0	52.9	55.5	64.3	60.1
Not in the same municipality	19.7	19.8	28.7	26.2	27.1	23.5
Not in the same county	13.9	19.2	18.4	18.3	8.5	16.4
Respondents attendance rate at the estate (%)* **						
Living on the estate	51.9	62.6	44.6	50.0	68.8	55.3
>10 times/year	37.4	25.2	40.1	30.0	26.8	31.5
0-10 times/year	10.7	12.2	15.3	20.0	4.5	13.2
Expected take-over (%)* **						
Own child	64.3	53.1	54.3	47.3	68.0	56.5
Other relative	8.7	4.6	8.1	6.5	6.3	6.6
Other solution	27.1	42.2	37.6	46.2	25.8	36.9
Income from the forest (%)* **						
<10%	75.1	59.5	93.6	86.1	47.2	72.1
10-49%	22.4	29.9	6.4	13.4	40.2	22.5
≥50%	2.4	10.6	0	0.5	12.6	5.4
Interest in buying land (%) **						
Yes	16.3	15.3	9.8	12.6	18.9	14.5
No	52.9	52.8	57.5	66.8	44.1	55.2
Do not know	30.8	31.9	32.8	20.5	37.0	30.3
Education level (%)*						
Compulsory school	37.8	34.7	31.2	40.4	47.3	37.4
Secondary school	25.4	35.8	30.5	24.0	27.3	29.4
Post-gymnasium	36.8	29.5	38.3	35.7	25.5	33.2

*, **, *** The distribution between the five clusters differs significantly according to a chi-square test at the 0.05, 0.01 and 0.001 probability levels, respectively.

Future trends

Most owners do not believe there will be a difference in five years time (Figure 4). Those who do believe there will be a difference (about 30% of the respondents) seem to think that the objectives of importance today will increase in importance in the future. This could possibly lead to larger differences developing between the groups.

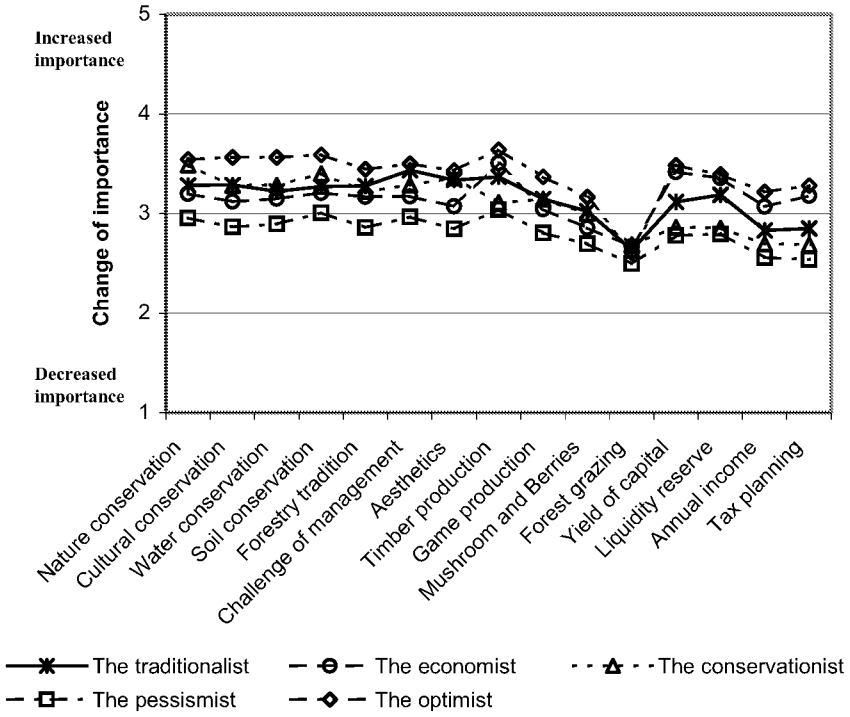

Figure 4. Future change of importance of each objective, in five years time, according to each cluster of forest owners.

Discussion

Sources of errors

One of the weaknesses of surveys in general is that the units of analysis are the clusters of traits, rather than the individuals. Another weakness is that each question can be interpreted in different ways by different respondents, so it is difficult to evaluate the quality of the data. Use of pre-determined and multiple-choice questions requires the researcher to know a priori what questions and responses are of importance. For basic socio-economic characteristics such as age

and sex, this does not pose problems, but for characteristics such as attitudes and objectives, appropriate categories are seldom known a priori (Bliss & Martin 1989). In an attempt to minimise these weaknesses the present study was preceded by an open-ended qualitative study, presented by Hugosson & Ingemarson (2004), determining the content of the questions concerning the forest owners' objectives.

The forest owners are a heterogeneous group, which could cause sampling errors. Certain forest owners will not get a chance to answer the questionnaire, even if a random sample is surveyed. In the present study, a random sample in sufficient numbers was taken, which should provide the desired level of precision (Dillman 1991). The clustering procedure was based on a stratified forest owner sample, with overrepresentation of owners of large estates. This was done to ensure there was a sufficient sample of the relatively few owners who own the main proportion of the forest area. If the cluster procedure had been carried out on a fully representative sample of the population, the small owners would have dominated and probably homogenised the five clusters presented in figure 3. Since this study was largely explorative in the meaning of finding and define new groups of forest owners' this would not have been desirable.

To avoid measurement errors questions should be phrased in ways that allow them to be correctly interpreted by the respondents. The clear clustering groups indicate that the forest owners have not misread or misunderstood the meaning of the objectives or failed to answer the survey questions correctly.

The impact of the non-response could be reduced, for example by taking a sample of non-respondents and extrapolating their characteristics to all of the respondents (Kanuk & Berenson 1975). The proportion of women was lower among the respondents compared to the non-respondents. The number of additional answers from female forest owners required to get an even distribution between the sexes was 42, equivalent to a proportion of about 3.5% of the total number of answers. This implies that even if the women had very different objectives, the effect on the total results in this study due to non-response bias would be insignificant.

In previous studies, it has been found that people who are interested in a given topic and are involved in the activities under study respond more frequently or promptly than less interested people (Dillman 1991, Martin 1994). In the present case, the representativeness of the five clusters could be affected by this tendency. A possible result could be, for example, that 'the optimists' were over-represented and 'the pessimists' underrepresented. Since the motive for this study was to determine the distribution of certain unknown characteristics, a comparison could not be done. Therefore, it was not possible to classify the non-respondents into the different types. This is a well-known problem (Dillman 1991), although a limited number of comparisons could be made for some variables.

The typology of forest owners

No traits that were not mentioned in the earlier study by Hugosson & Ingemarson (2004) emerged from the analysis of the questionnaires. For example, 'the position of owning land' was mentioned, but it is not an objective according to the empirical model, as the objectives should concern particular types of action. Another trait mentioned was 'recreation', which is considered to include several other objectives, for example 'game production' and 'aesthetics' (Hugosson & Ingemarson 2004). The analysis shows that the suggested model covers a wide range of objectives and that any additional objective must be considered very rare among Swedish forest owners. The clustering of the objectives detected in the cluster analysis (Figure 2) had strong similarities to the structure of the objectives suggested by the professional foresters (Table 1), except for 'timber production'. According to the forest owners in the cited study this objective was considered to be closely related to 'yield of capital', resulting in 'timber production' being taken away from the structure of objectives according to the forest owners. Thus, the separation of 'timber production' is supported by the earlier qualitative study.

Five different types of forest owners were identified solely using cluster analysis of the importance of objectives stated by the respondents themselves. This means that the respondents were able to discriminate between the different objectives and to express their differences. The clusters proved to have significantly different typologies (Table 4 and 5), supporting the hypothesis that small-scale forest owners have become increasingly diversified (Marty *et al.* (1988), Karppinen 1998b *a.o.*). This indicates that the model presented by Hugosson & Ingemarson (2004) is a useful tool for future research into forest owners' behaviour. Questions raised in the introduction were answered. Conservation-oriented forest owners were younger and were city-dwellers. 'Forest tradition' was most important among owners born on the estate they own, and had acquired from the family. Economically interested forest owners held larger estates, but their educational levels were intermediate.

The most important reason for changes in forest owners' objectives is considered a generational change, when people with different objectives, occupations and educational levels become forest owners through ownership transfers (Inglehart 1977, Karppinen 1998a). This is supported by the present study. The majority of the forest owners did not believe the importance of their objectives would change within five years. The average ownership tenure in Sweden is 15-25 years (Eriksson 1989a).

Forest owners with different objectives may very well react differently with respect to certain forest policy issues. By studying Austrian forestry professionals, Pregernig (2001) showed that different types of forest owners respond to policy instruments in different, specific ways. The results of Pregernig (2001) combined with the results of this study provided an opportunity for suggesting how forest owners in different clusters would respond to different policy instruments. For example, 'the optimist' could be influenced by regulatory instruments, while 'the pessimist' could be difficult to convince. 'The conservationist' is probably

sceptical of many types of policy instruments. 'The traditionalists', holding an intermediate position, should be a good target group for several types of policy instruments. 'The economist' will probably follow policies if they are consistent with financial objectives. The forest owners' objectives may depend upon the environment in each country, but the methodology has a broader application. Further studies could focus on preferences of the different clusters with regard to silvicultural management activities, levels of cuttings and the influence of different policy tools.

The different importances (weights) of the objectives could be used as a starting point for choosing different planning alternatives. One possibility is to use a 'priority function' for weighting different multiple criteria, *e.g.* by Kangas (1992). However, the additive linear function is also limited, for example, the functions have to be constant linear, and one problem is how the criteria should be operationalised.

Professional foresters in daily contact with forest owners can use the results from this study to identify different owner groups. Future forestry management should be adapted to the forest owners' objectives shown in this and in similar studies.

Conclusions

- The qualitative study by Hugosson & Ingemarson (2004) seems to be valid.
- Clear sub-groups of forest owners' can be differentiated by their objectives.
- The quantification of the background variables of the clusters was successful, which is crucial for application of the results (Karppinen 1998b).
- The results confirm recent studies (Bengston & Xu 1994, Karpinnen 1998a *a.o.*) that a sole emphasis on economic benefits is not desirable from the forest owners' point of view.

Acknowledgements

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IV

Evaluation of silvicultural practices from a multipurpose perspective

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Abstract

Appropriate silvicultural practices, based on the objectives of forest owners, should be incorporated into forest management plans to promote sustainability. The main objective of this study was to evaluate the suitability of different silvicultural practices with respect to the multiple objectives of small-scale forest owners. In addition, a method for evaluating the results of research within the field is presented. A model describing the objectives of private forest owners was used to compare different silvicultural practices. A literature review was conducted and the appropriateness of different practices and objectives was analysed using matrixes. The results indicated that the practices evaluated have the potential to allow the development of forestry with multiple functions: thinning and successive felling appeared to be most suitable. Passive practices were less well adapted to the multiple objectives of private forest owners. It is important to continue collating and reviewing the available data, especially relating to forestry practices not commonly used in Scandinavia.

Key words: amenities, conservation, economic efficiency, forest management plans, forest owners' motivations, forest owners' values, multipurpose forestry, silvicultural systems, utilities.

Introduction

Appropriate silvicultural practices, based on the objectives of the forest owners, should be incorporated into forest management plans to promote sustainability. The forest owners' rights and obligations during forest management are regulated by the Swedish Forestry Act. The first paragraph states: "The forest.... shall be managed in such a way as to provide a valuable yield and at the same time preserve biodiversity. Forest management shall also take into account other public interests" (National Board of Forestry 1994, p.8). At the same time, the regulations of the Act are not detailed, leaving decisions largely to the forest owner. For example, in the previous Act a forest management plan had to be produced, but in the new Act of 1994 this is no longer a requirement. Forest ownership in Sweden can be divided into four types: private, company, state, and community forests. With about 400 000 owners and an average estate size of about 45 hectares, private holdings encompass approximately 50 percent of the total area of forest, or 10.7 million hectares (Enström 1997). Approximately one quarter of forest owners earn

at least part of their living through forest-related activities (Lidestav & Nordfjell 2002). The most commonly used silvicultural practices are clear cutting, followed by planting, cleaning and thinning (National Board of Forestry 1998). The structure of forest ownership is changing in Sweden and the economic importance of the forests is deceasing for the small-scale owners (Hugosson & Ingemarson 2004), sometimes referred to as non-industrial, smallholder or family forestry (Harrison *et al.* 2002). Changes in legislation during the 1990s resulted in deregulation of the property market. Farmers' pre-emptive rights were largely terminated, possibly resulting in a larger proportion of forest owners who belong to a new generation with different values. They are concerned not only with wood production and profit, but also, for example, with conservation and amenity (Hugosson & Ingemarson 2004). The result shows that small-scale forest owners could have many different objectives that affect silvicultural practices in different ways.

The main objective of the present study was to evaluate the suitability of different silvicultural practices for fulfilling multiple objectives. In addition, a method for evaluating the results of research within the field is presented. A literature review was conducted, followed by an analysis of the relationships between silvicultural practices and the objectives of forest owners. The evaluation is intended to be used as a foundation for decision-making by small-scale forest owners. A practice may be well adapted to one objective, but be less suited to another. The following examples illustrate the type of problems discussed herein:

- Clear cutting is economically sound, but increases both leaching soil erosion.
- Leaving an old forest undisturbed may be appropriate for nature conservation, but not if the owner requires a high economic return.

Material and methods

A model describing private forest owners' objectives (Hugosson & Ingemarsson 2004) was used to compare the different practices. The objectives from the model are described below. The cluster of objectives entitled 'conservation' relates to careful management of forest resources for protection and preservation. The objective 'nature conservation' refers to the creation of opportunities for a rich and varied plant and animal life, including biodiversity. 'Cultural conservation' represents the desire to protect and preserve historic and cultural features. 'Water/Soil conservation' relates to managing water systems in a way that will not adversely affect the water quality, and protecting the soil from leaching and loss of nutrients. The cluster entitled 'utilities' relates to producing a range of forest products. The objective 'game production' represents a desire to improve habitats and increase the amount of forage for game, in this study limited to deer. The objective 'berry production' concerns cowberries (*Vaccinium vitis-idaea L.*), bilberries (*Vaccincum myrtillus L.*) and raspberries (*Rubus idaeus L.*). 'Mushroom production' concerns harvesting mushrooms. The cluster entitled 'amenities' has a weaker connection to activities than the other motivations and accordingly, is more

related to underlying values. 'Forestry tradition' represents the desire to manage forests for previous and future generations, maintaining continuity of the forest structure. 'Silvicultural challenge' concerns forest management as a source of intellectual and physical challenges. The objective 'aesthetics' relates to the visual appearance of the forest. The cluster 'economic efficiency' reflects economic objectives for managing forest land. The objective 'yield of capital' concerns the creation of opportunities for a high financial return from forestry. If the forest owner regards the forest as a 'liquidity reserve', forestry probably does not provide his/her primary income. For example, the economic output of the forest may be used by a farmer during years with poor crops. 'Tax planning' determines when and what type of management activities should be carried out, depending on the tax system and the structure of the forest (Hugosson & Ingemarsson 2004).

The relationships between practices and forest owners' objectives were analysed. The results of the literature review were summarised in the form of matrixes, with the clusters of objectives on one axis and silviculture practices on the other. One matrix was constructed for each cluster of objectives, i.e. 'conservation', 'amenities', 'utilities' and 'economic efficiency'. Each cell was allocated a level of adaptation and the levels were summarized using the following variables: A for adapted (1); P for partly adapted (0); and N for not adapted (-1). Following Gustafsson (1998), a system for reviewing the references was used, allocating stars according to their validity:

*** Refereed articles or monographs
** Scientific reports and textbooks
* Inadequate reference

The star system maps the documented knowledge for the area under consideration, thus areas lacking research were apparent on the matrixes. In such cases, the evaluations were based upon interpolations and common knowledge. The suitability of each practice was evaluated individually and summarised (Tables 1 to 4). Horizontally, the summation included the scores for each individual practice. Vertically, the summation of practices demonstrated their suitability for each individual objective. Finally, Table 5 shows the level of suitability for the multiple objectives of small-scale forest owners. There are large numbers of forest owners, representing a wide variety of values, and for whom the different objectives assume different levels of importance. This is not taken into account in the summations, but a proposal for how to handle this issue is described under the heading 'Applications'.

The practices were analysed at forest stand level during a period of twenty years. This period was chosen for several reasons. First, properties tend to change owners during such a period: on average, a Swedish owner possesses the forest for about twenty years (Eriksson 1989). Second, this period is a time suitable for surveying; after twenty years the forest has developed into a new age class and a new silvicultural practice is often necessary. Over a longer period of time it would be difficult to gain an overview. If the period considered were a rotation, the analysis would have been on the level of systems, rather than practices. The latter was not

within the scope of this study, but a rough outline, with a comparison between two silvicultural systems is presented in the discussion. The stands referred to were assumed to have a history and pre treatment such that the practices would function without severe risk. The tree species were limited to Scots pine (*Pinus sylvestris L.*) and Norway spruce (*Picea abies Karst.*) in their natural habitat: other species could be kept in the stand for biodiversity purposes. Although the emphasis was on the most common practices related to clear cutting and uniform shelterwood systems (Matthews 1989), other practices, related to silvicultural systems in Central Europe that could be adapted to Scandinavia, are also discussed. 'Silvicultural system' was defined as "the process by which the crops constituting a forest stand are tended, removed, and replaced by new crops, resulting in the production of stands of a distinct form" (Matthews 1989, p. 3). The term 'Silvicultural practices' refers to techniques for managing forest compartments such as felling, tending, regeneration, etc. They are, in general, active (felling, planting and burning), but there are exceptions (no felling, no cleaning). 'Stand' is the "basic management unit of a forest" (Hibberd 1991, p.148), while 'compartments' are "permanent management units" (*Ibid.*)

Definitions of forestry practices

Clear cut referred the 'original form'; *i.e.* no Green Tree Retention (GTR) after harvesting. Successive felling corresponded to 'uniform felling' (Matthews 1989) and was achieved in two steps, with a reduction of the number of trees to 80-150 stems ha^{-1} followed by a clear cut 10-12 years later. In addition, it was assumed that the first intervention had been preceded by a thinning 20 years previously, thus leading to a relatively storm resistant stand. However, stand density was considered to reach and exceed 1,0 if no intervention (*e.g.* thinning) was conducted during the next 20 years. 'No felling' was a 'non-active practice', mentioned because forest certification rules state that a certain percentage of the forest should be left for free development - without human intervention. This will lead to a 'virgin' forest stand at the end of the period. Scarification was performed mechanically by uncovering the mineral soil in patches or in ranges (disc trenching) or by mounding. Ploughing was excluded from this study. Prescribed burning was used to create habitats for red listed species, and to promote the establishment of young stands of Scots pine (Skinnemoen 1969 *a.o.*). Planting was performed in a 'traditional way', resulting in a young forest with evenly spaced trees growing in ranges. Manual scarification was also included as part of the practice. Sowing was preceded by an efficient mechanical scarification. Natural regeneration under uniform shelter (NUS) referred to a shelterwood (Börset 1986) of 120-150 stems ha^{-1}, created to produce seed, shelter and high quality timber, with removal after 12-15 years. Natural regeneration under irregular shelter (NIS) was comparable to the 'Group System' (Matthews 1989), which involved taking up 'initial gaps'. The practice also included at least one extension of the gap during the 20 year period. The stand was assumed to have been well tended earlier during the rotation. NIS may also include planting to obtain a mixture of species. Natural regeneration at forest edges (NFE) was understood to be the initial steps of the Strip System, which also constitutes a

"side shelter" (a shelterwood system) (Matthews 1989, p. 90). Cleaning referred to 'conventional cleaning', consisting of one heavy cleaning, leaving 1500-3000 stems ha-1, depending on the site index, at a stand height of 2-3 m. Generally, conifer stems were favoured, but deciduous trees are frequently left in the stand. Thinning referred to 'free Danish thinning' (Söderström 1971). Absence of cleaning and of thinning were also evaluated because they are not obligatory under the Swedish Forestry Act, and some forest owners do not tend their forest stands (National Board of Forestry 1995, 2002a).

Results of the evaluation

Conservation (Table 1)

'Culture conservation' refers to opening up areas, *i.e.* removing vegetation, in order to allow prehistoric graves, old ruins *etc.* to become visible within the landscape (Andersson 2000, Gustavsson 2000), thus preventing damage by roots and stopping trees from concealing the area. This is the principle when clear cut is used, but this practice may be too rigid and aggressive, since large areas are treated systematically with heavy machinery (Gren 1997). The taller a tree, the greater the risk of windthrow (Burschel & Huss 1997). Successive felling in old stands is therefore inappropriate in an area where culture conservation is the aim, since it can damage prehistoric graves or other remains (Andersson 2000). Virgin forest is never opened up in a controlled way (Buschel & Huss 1997 *a.o.*), and obscures historic monuments. Scarification of grave sites is not permitted, thus precluding regeneration by sowing (SFS 1988:950). Since the protection of objects of cultural value often involves the removal of vegetation and maintaining open areas, all practices with the objective of regeneration are more or less unsuitable. In such cases, planting is strictly forbidden by Swedish law (SFS 1988:950). NIS and NFE present the same problems as NUS – *i.e.* the risk of windthrow, but to a lesser extent (Matthews 1989, Burschel & Huss 1997). If not removed, young forest compartments should be tended in a way that leads towards stability. It is recommended that thinning should be confined to the early stages of stand development, during the thicket stage (Matthews 1989, Cameron 2002).

Forestry practices that radically change the forest are generally considered inappropriate for nature conservation. Vanha-Majamaa & Jalonen (2001) find that clear cutting caused major understory vegetation changes. Cover and species number of both bryophytes and many vascular plants decrease. However, clear cutting does not always impoverish the flora. Kardell & Lindhagen (1998) find that shade-tolerant species disappear after clear cutting but are replaced by light demanding species. The number of species remains the same, or even increases in a clear-cut area. Different forms of successive felling result in fragmentation, which creates habitats for various plants and leads to increased occupancy of edge habitats (Esseen 1994). Consequently, it is likely that felling to create smaller gaps maintains a larger number of species. Uniform shelterwood is sometimes recommended as it is considered ecologically more valuable than clear felling

(Ingelög 1981, Bergquist *et al.* 2001). Shelterwood maintains the number of species at the pre-treatment level, but the cover of shade tolerant plants may decrease (Vanha-Majamaa & Jalonen 2001). Although an absence of felling is, in part, beneficial for biodiversity (especially mosses, lichens, fungi and insects) it can be detrimental for some herbaceous plants and tree species. A stand density approaching 1.0 or more is not recommended (Ingelög 1981), unless only shade-tolerant species are required. Forest regeneration using the same species that was present before harvesting supports nature conservation by providing vascular plants with an opportunity to re-establish after a clear cut (National Environmental Protection agency 1994), but planting or sowing of a single tree species creates monocultures. However, such practices are often combined with scarification, which although sometimes considered to have a negative impact (Buschel & Huss 1997), is positive for biodiversity. The number of naturally regenerated birch seedlings (*Betula pendula Roth.* and *Betula pubescens Ehrh.*) is considerably higher on scarified than on non-scarified areas (Folkesson & Johansson 1981, Karlsson *et al.* 2002), at least on mesic and moist ground (Fries 1985). Burning is often considered a natural component of boreal ecosystems, since burnt trees provide a variety of substrates used by insect species, indeed some are completely fire-dependent (Ehnström 2001). Burning causes chemical and physical changes in the forest soil. These are important for the germination of forest tree seeds, particularly aspen (*Populus tremula L.*) and sallow (*Salix caprea L.*), two species important for creating biodiversity (Granström *et al.* 1995). NFE creates special light conditions, which permit the regeneration of shade-tolerant species, such as Norway spruce, as well as the survival of light demanding species (Matthews 1989, Buschel & Huss 1997). This is also the case for NIS, but to a less extent (*Ibid.*).

Tending forests creates opportunities for a rich and varied vascular plants composition, including different tree species (Ingelög 1981). Even though various tending practices can enhance nature conservation, some can be detrimental. If a forest owner favours one particular tree species then diversity is reduced (*Ibid.*). Cleaning and thinning tend to leave equal distances between the trees and increase the uniformity of the forest, unlike natural virgin forest (*Ibid.*). Targeted thinning of rotten and hollow trees has a negative impact both on the wildlife (birds and bats) and on the diversity of insects, cryptogams and fungi (Ehnström 2001, Nilsson *et al.* 2001). From this perspective, absence of tending is more suited to nature conservation, especially since it also favours the creation of dead wood. However, absence of tending often result in a high stand density, thus reducing the diversity of tree species (Schütz 1997, Otto 1998) and herbaceous plants (Ingelög 1981, National Environmental Protection Agency 1994), of which only shade-tolerant species can survive. Skidding roads, created as part of thinning operations, often become refuges for rare or threaten forest plants, such us calypso (*Calypso bulbosa (L.)* Oakes) and hard fern (*Blechnum spicant (L.)Roth*) (Ingelög 1981).

Opening up the canopy on a large scale may cause several problems with respect to water and soil conservation. This can expose the site to erosion, because there is no protection against rapid run-off of rainwater (Matthews 1989, Burschel & Huss 1997). These problems are less severe when shelter trees are left in the area (Burschel & Huss 1997). The absence of felling and tending in a stand may be

appropriate for water and soil conservation, but not if this causes forest degeneration (Lanier 1994). Regeneration practices aim at rapid re-colonisation of the harvested area, which has a positive impact on water retention (Savill et al. 1997). In Nordic ecosystems, neither burning nor scarification have a negative impact if they are conducted moderately and on appropriate sites (Johansson 1987, Lundmark 1988, Gemmel & Örlander 1989). Burning on sites with a thin humus layer reduces fertility of the soil (Kardell & Laestadius 1987), especially for Norway spruce (Lundmark 1988).

NIS and NFE appeared to be suitable for conservation purposes (Table 1). Absence of tending, clear cutting and successive felling produced low scores. The sum for the column 'culture conservation' was low.

Table 1. Suitability of the various practices to deliver 'conservation' objectives

	Culture conservation	Nature conservation	Water/Soil conservation	Sum	Numeric sum
Clear cutting	P **	P ***	N **	2P+N	-1
Successive felling	N **	P ***	P **	2P+N	-1
No felling	N **	P **	P **	2P+N	-1
Scarification	N ***	P **	A **	A+P+N	0
Burning	N *	A **	P **	A+P+N	0
Planting	N ***	P **	A **	A+P+N	0
Sowing	N ***	P **	A **	A+P+N	0
NUS	N **	P **	A **	A+P+N	0
NIS	P **	A **	A **	2A+P	2
NFE	P **	A **	A **	2A+P	2
Cleaning	P **	P **	A **	A+2P	1
No cleaning	N **	P **	P **	2P+N	-1
Thinning	P **	P **	A **	A+2P	1
No thinning	N **	P **	P **	2P+N	-1
Sum	5P+9N	3A+11P	8A+5P+N	11A+21P+10N	1
Numeric sum	-9	3	7		1
Inadequately documented (%)	7.1	0.0	0.0	mean:	2.4

*** High validity, * Low validity, A - adapted (1), P - partly adapted (0), N - not adapted (-1)

Utilities (Table 2)

Clear cut creates space for broadleaf trees, raspberries and herbaceous plants, all important for game production (Ahlén *et al.* 1979, Cederlund *et al.* 1980, Börset 1986). This may be the case for all forms of successive felling and natural regeneration (Ahlén *et al.* 1979). Absence of felling causes excessive competition between the canopy species and species providing fodder for game. A boreal virgin forest may produce little game fodder (Hermansson *et al.* 1974). Therefore, it may be necessary to open up older stands to allow the establishment of appropriate

species. Establishing a new crop also means producing food for game (Savill *et al.* 1997, National Board of Forestry 1998). Scarification has a positive influence on game food supply, resulting in a high number of broadleaf species (Folkesson & Johansson 1981), but has a negative impact on sprigs (Kardell & Eriksson 1983), which are important food sources for roe deer (*Capreolus capreolus L.*) and moose (*Alces alces L.*) (Ahlén 1977, Börset 1986, Cederlund *et al.* 1980). Deer, in general, respond favourably to fires (Spurr & Barnes 1980). Cleaning in young coniferous stands often removes broadleaf species, but some practices can be game-friendly. Cleaning, by cutting the tops off trees such as birch, rowan (*Sorbus aucuparia L.*) and different Salix-species, produces fodder and shelter, which are utilised by many kinds of game (Hermansson *et al.* 1974). Opening up a dense stand creates space for the growth of broadleaf tree species and herbs. An absence of cleaning is initially good for game production because existing deciduous trees (and other fodder species) remain in the compartment, and the vegetation provides shelter (*Ibid.*). Thinning is necessary, however, to maintain the production of game fodder. An absence of thinning restricts the opportunities for wildlife conservation (Cameron 2002).

Clear-cutting influences the production of berries in a variety ways. Raspberry and cowberry production is positively influenced by clear cutting (Kardell & Eriksson 1990). Bilberry generally supports a lower biomass in a clear-cut area than under a shelterwood (Hannerz & Hånell 1993, Öhman 1997) It is, however, favoured by clear cutting where temperature is a limiting factor, for example in areas of high exposure and in northern Sweden. In southern Sweden, bilberry production is adversely affected by this practice, especially on south-facing slopes (Kardell & Eriksson 1990). However, in terms of annual production (kg ha^{-1}), irrespective of berry species, clear cutting is undoubtedly very efficient (Kardell 1993). Different forms of successive felling lead to fragmentation that creates habitats for a variety of plants (Esseen 1994); opening up old forest stands favours the production of bilberry and cowberry (Kardell & Eriksson 1989). Burning and scarification are beneficial for raspberry production, but not for cowberry and bilberry (Kardell & Eriksson 1990). The influence of different regeneration practices, and the impact that a gradually closing tree canopy might have on berry production is not well documented (Kardell & Eriksson 1983). Production of raspberry and cowberry is initially high in a newly regenerated area (Kardell 1993), but active practices are supposed to increase the competition from the new generation of trees by the end of the 20 year period. Compared to a lack of intervention, thinning appears to have a positive influence on berry production (Kardell & Eriksson 1990). Cleaning was considered to have a similar positive influence.

Five years after a clear-cut the production of edible mushrooms is only 5% of the quantity usually found in an untreated stand (Kardell & Eriksson 1987). If 50-100 seed trees are left per hectare, the production of mushrooms is 30% of the production in an untreated stand (*Ibid.*) Successive felling, including different forms of natural regeneration, are thus partly suitable. In scarified areas, the production of edible morels (*Gyromitra esculénta (Pers.) Fr.*) is double that of non-scarified areas (Kardell & Eriksson 1987). Low intensity fires seem to have a

limited long term effect on mycorrhizal diversity and community composition (Jonsson *et al.* 1999). The presence of tree roots is essential for fulfilling the life cycle of mycorrhizal fungi such as ceps (*Boletus edulis Fr.*) (Otto 1998). It was presumed that a rapid re-colonization by forest trees has a slight positive impact on the production of mushroom. Production of edible mushrooms tends to be the same in thinned and non thinned compartments (Kardell & Eriksson 1987).

Thinning was the only practice appropriate for all three objectives (Table 2). Successive felling and cleaning were also useful, but inactivity was less appropriate.

Table 2. Suitability of the various practices to deliver 'utility' objectives

	Game production	Berry production	Mushroom production	Sum:	Numeric sum
Clear cutting	A ***	A **	N **	2A+N	1
Successive felling	A **	A **	P **	2A+P	2
No felling	N **	N **	A **	A+2N	-1
Scarification	P **	P **	A **	A+2P	1
Burning	A **	P **	P ***	A+2P	1
Planting	A **	P *	P *	A+2P	1
Sowing	A **	P *	P *	A+2P	1
NUS	A **	P *	P **	A+2P	1
NIS	A **	P *	P *	A+2P	1
NFE	A **	P *	P *	A+2P	1
Cleaning	P **	A *	A **	2A+P	2
No cleaning	A **	N *	A **	2A+N	1
Thinning	A ***	A **	A **	3A	3
No thinning	N ***	N **	A **	A+2N	-1
Sum	10A+2P+2N	3A+8P+3N	6A+7P+N	19A+17P+6N	14
Numeric sum	8	0	5		14
Inadequately documented (%)	0.0	50.5	28.6	Mean:	26.2

Amenities (Table 3)

Clear cutting may be linked to a desire to manage the forest for future generations, but the operation involves drastic changes at the stand level (Burschel & Huss 1997). Successive felling results in gradual changes and is therefore better suited to a continuation of forestry tradition (Nyland 1996 *a.o.*). There are no radical changes in the absence of felling, but it was not considered beneficial for future generations. The feeling of leaving a well-tended forest to future generations is a very important motivation for the forest owner when regenerating and tending (Sennblad 1990). Burning is an exception as it drastically changes the appearance of an area (Nyland 1996). For the same reason, scarification was also considered

an exception. By being passive, the forest owner is not taking care of the legacy of previous and future generations (Sennblad 1990). In Finland, postponement of the first thinning has been seen as one of the most serious threats to sustainable forestry (Hyytiäinen & Tahvonen 2002).

Clear cutting is a reliable way of harvesting a crop (Matthews 1989 *a.o.*) and it is seldom an activity undertaken personally by the owner, therefore, clear-cutting provides no silvicultural challenges. Creating a shelterwood by successive felling can fulfil this need. It is not necessarily a personal activity, but the practice itself is challenging, as it requires an instinctive feeling for minimising the risk of wind thrown trees and for producing good quality regeneration (Hagner 1962 *a.o.*). The same principle applies to the regeneration at forest edges and in irregular shelterwoods (Matthews 1989, Schütz 1997, *a.o.*). Scarification is reliable and does not involve personal activity, whereas burning an area in the forest in a controlled way demands skill (Nyland 1996). Planting and sowing may at least offer the owner opportunities for physical activity and skill (Söderström 1971). Sowing was considered more challenging than planting: its success requires more skill. Tending also requires skill on the part of the forest owner and provides the opportunity for physical activity. Undemanding passive practices present no silvicultural challenges.

Shelterwoods are more aesthetically pleasing than clear–cuts (Bergquist *et al.* 2001); large areas of clear-cut are not aesthetically valuable (Kardell 1990, Kardell and Lindhagen 1998). Old untouched forests are usually valued (*Ibid.*), but if no felling takes place, the structure of the forest may change in an uncontrolled way. Whether an area of forest is aesthetically pleasing depends on previous management (*Ibid.*). Virgin forests are still considered unsuitable for recreation by the majority of Swedish people (Lindhagen & Hörnsten 1997). A burned area is, initially, not very attractive, but produces vigorous stands after a few years (Skinnmoen 1969). Scarification, planting and sowing produce regeneration in blocks, often with equal distances between the plants, which tends to be unattractive (Kardell & Lindhagen 1998). However, after a few years plant mortality and natural regeneration will improve the aesthetics. Attitudes towards young stands are often neutral unless it does not obscure the view (Kardell 1990). NIS is generally considered beautiful (Matthews 1989 *a.o.*), whereas NFE often results in a rigid geometric layout (*Ibid.*). Young stands, tall enough to obscure views, often have dry ugly twigs. This is unappealing to those walking in the forest, and is a particular problem where the trees are not tended (Kardell & Lindhagen 1998). Newly cleaned or thinned areas are also unattractive because of the presence of logging wastes, however, mature, well-thinned, middle-aged and open stands are appreciated (*Ibid.*). Kardell (1990) concludes that tending raises the aesthetic value of a forest even if it is delayed. An absence of tending restricts the opportunities for enhancing visual appearance (Cameron 2002).

Successive felling, the main regeneration practices (especially different forms of shelter) and active tending were appropriate in supporting the objectives of the amenities cluster (Table 3). Clear cutting and passive practices were not appropriate.

Table 3. Suitability of the various practices to deliver 'amenities' objectives

	Forestry tradition	Silvicultural challenges	Aesthetics	Sum	Numeric sum
Clear cutting	P **	N **	N ***	P+2N	-2
Successive felling	A **	A **	A ***	3A	3
No felling	P **	N *	P **	2P+N	-1
Scarification	P *	N **	P **	2P+N	-1
Burning	P **	A **	P **	A+2P	1
Planting	A **	P **	P **	A+2P	1
Sowing	A **	A **	P **	2A+P	2
NUS	A **	A **	A **	3A	3
NIS	A **	A **	A **	3A	3
NFE	A **	A **	P **	2A+P	2
Cleaning	A **	A *	P ***	2A+P	2
No cleaning	P **	N *	N ***	P+2N	-2
Thinning	A **	A *	A ***	3A	3
No thinning	P **	N *	N ***	P+2N	-2
Sum	8A+6P	8A+P+5N	4A+7P+3N	20A+13P+8N	12
Numeric sum	8	3	1		12
Inadequately documented (%)	7.1	35.7	0.0	Mean:	14.3

Economic Efficiency (Table 4)

A high yield of capital is achieved if the stand is clear cut in time to produce the maximum net present value (NPV) with respect to the land value (Streyffert 1965). NIS and NFE were considered only partially suitable, since not all trees in the compartment are cut. Creating a shelterwood by successive felling and NUS, makes it possible to concentrate and maintain production on the trees most suited to maximising NPV (*Ibid.*) and allows the proportion of saw logs to be maximised (Hånell *et al.* 2000). When no felling is undertaken, the increment as well as the yield of capital decreases (Streyffert 1965). Increases in interest rates calculated for costing purposes render regenerative practices, for example planting and sowing, less profitable (Håkansson 2002). An interest rate of 3% makes it hard to maintain a high yield of capital on cultivation costs (Streyffert 1965); only the most productive sites will yield profits from planting and sowing (Håkansson 2002). Scarification, which involves relatively low costs, was considered an exception. Cleaning and thinning produce early harvest revenues and increase the value of the residual trees (Hyytiäineen & Tahvonen 2002, Streyffert 1965). The production of high quality saw logs is restricted if there is no tending (Cameron 2002) and long intervals between thinning can result in a reduction in volume production (Assmann 1970). Investment in shelter decreases the liquidity reserve, but only temporarily. The remaining trees in a shelter, and trees in stands after commercial thinning, represent reserves as well as production potential (Streyffert 1965). This

is of particular interest when maximizing the proportion of saw logs (Hånell *et al.* 2000). In contrast, clear cutting leaves no such reserves (*Ibid.*). In the absence of unforeseen events, the owner will have some liquidity reserve if there is no final felling, but this was not considered efficient. The costs of regeneration decrease the reserve (Streyffert 1965) and a period of twenty years is too short to convert the associated production into cash. Cleaning is costly, and reduces liquidity, but it has the potential to produce a reserve after twenty years, which is not possible with no cleaning. Thinning was considered beneficial.

Harvesting practices, regeneration under shelters and at forest edges are adapted to tax planning, since the income can be spread over several years (Håkansson 2002). An absence of felling and thinning creates no opportunities for tax planning, except by avoiding income (*Ibid.*). Swedish fiscal legislation considers planting to be an investment and is therefore an operative expense, which can reduce taxes, especially as the costs for regeneration can be spread over time (Ibid.). Income from business can, under some circumstances, be offset against a loss through forestry management practices, for example investments in regeneration and tending. An absence of cleaning provides no opportunities for tax planning. Another means of reducing taxes results from the fact that income from forestry and other businesses can be jointly taxed. Income from the forest can be considered as income from capital, according to the interest rates; income from capital is taxed at a lower rate business (Håkansson 2002).

Successive felling, regeneration under different shelters, cleaning and thinning were well suited to economic efficiency (Table 4). Not cleaning had no economic efficiency benefits.

Table 4. Suitability of the various practices to deliver 'economic efficiency' objectives

	Yield of Capital	Liquidity reserves	Tax planning	Sum	Numeric sum
Clear cutting	A **	N ***	A ***	2A+N	1
Successive felling	A ***	A ***	A ***	3A	3
No felling	N **	P *	P ***	2P+N	-1
Scarification	P *	N **	A ***	A+P+N	0
Burning	N **	N **	A ***	A+2N	-1
Planting	N **	N **	A ***	A+2N	-1
Sowing	N **	N **	A ***	A+2N	-1
NUS	A ***	A ***	A *	3A	3
NIS	P *	A ***	A *	2A+P	2
NFE	P *	A **	A *	2A+P	2
Cleaning	A ***	P *	A ***	2A+P	2
No cleaning	N ***	N *	N *	3N	-3
Thinning	A ***	A *	A ***	3A	3
No thinning	N ***	P *	P ***	2P+N	-1
Sum	5A+3P+6N	5A+3P+6N	11A+2P+N	21A+8P+13N	8
Numeric sum	-1	-1	10		8
Inadequately documented (%)	21.4	31.7	28.6	Mean:	28.6

Summation of the four clusters (Table 5)

Combining the above results allowed an examination of the suitability of different practices for multipurpose forestry (Table 5). Thinning and NIS produced the highest scores, indicating that they were the most adaptable practices. NUS, NFE, cleaning and successive felling also emerged useful. Clear cut was less appropriate, and the least useful approach was passivity. The sum of the columns indicates the suitability of the practices for each of the clusters. The highest scores were for utilities and amenities; scores were lower for economy and were especially low for conservation.

Table 5. A summary of the level of suitability of various practices for the four clusters of objectives

All clusters of objectives	Conservation	Utilities	Amenities	Economic efficiency	Sum
Clear cutting	-1	1	-2	1	-1
Successive felling	-1	2	3	3	7
No felling	-1	-1	-1	-1	-4
Scarification	0	1	-1	0	0
Burning	0	1	1	-1	1
Planting	0	1	1	-1	1
Sowing	0	1	2	-1	2
NUS	0	1	3	3	7
NIS	2	1	3	2	8
NFE	2	1	2	2	7
Cleaning	1	2	2	2	7
No cleaning	-1	1	-2	-3	-5
Thinning	1	3	3	3	10
No thinning	-1	-1	-2	-1	-5
Sum	1	14	12	8	35
Inadequately documented (%)	2.0	26.2	14.3	28.6	Mean: 17.9

Discussion

The practices examined were suitable for forest owners who valued hunting, picking mushrooms, forestry traditions and aesthetics. Economic efficiency did not achieve a high score within the clusters. This may be because most of the practices considered were regenerative, reducing the liquidity reserves and requiring more than twenty years to produce a yield on investments. Another choice of model for describing the objectives of the forest owners would influence the results, as would a different choice of practices, however those presented here include the most common practices. The poor value for conservation was mainly due to the low scores for 'culture conservation', indicating that forestry is difficult to combine with the protection of areas of high cultural value (Hasselmo 2000). Excluding 'culture conservation' from the cluster makes the practices more useful. The majority were only partly suitable for 'nature conservation'. This is

understandable, since all intervention causes changes, which are positive for some organisms, but fatal for others (National Environmental Protection agency 1994). In view of this, the score allocated for 'burning' (adapted) is questionable. Under natural conditions, forest fires should affect 1% of the boreal forest area in Sweden annually (National Environmental Protection agency 1994), but fires have been rare in Swedish forestry for almost half a century. Burning undoubtedly has a mainly positive impact on biodiversity. 'Lack of dead wood' for example, seems to be less of a problem, since the volume of windthrow and standing dead trees has increased by about 30% since the 1950s (National Board of Forestry 2002b).

The practice 'no regeneration' was not analysed, since regeneration is a legal obligation under the Swedish Forestry Act. 'No scarification' was examined initially, but few references were found; it is still possible to make interpolations using the material referred to in the text. Green tree retention (GTR) was found to be unimportant for the majority of the objectives, except nature conservation. Modified forms of tending were initially considered, but there was little literature and the results did not differ much from traditional forms of cleaning and thinning. Tree species could influence the evaluation, but a focus on pine and spruce along with the prerequisites relating to risks resulted in small differences. For example, clear cutting was equally negative for soil and water conservation irrespective of tree species. Pine is preferable when producing game fodder and berries (Kardell & Eriksson 1983), but the structure and density of the stand has probably a bigger impact. Moreover, to make an evaluation for each tree species, four matrixes per species would be required.

The ranking presented here was based on interpretations from available literature based on research within the field. In some cases, such as for forest owners' preferences, there was a lack of adequate information. Available literature covered general opinions and not the specific opinions of forest owners. It was presumed that the forest owner's opinions did not differ from more general views (Mörk 2000). Occasionally the available literature only addressed part of the issue, for example with respect to 'nature conservation', even when a wide range of literature was available. There was also a lack of information on practices such as NIS and NFE under Scandinavian conditions. The objectives 'game production' and 'aesthetics' were well covered in the literature, but the remaining objectives require more research. Consequently, the evaluations from the matrixes may be affected by a certain amount of subjectivity, reflecting the cultural background of the authors.

The documented references (more than one star) covered 80% of the evaluations. In the cases where references were missing, the validations were tested. First, all such evaluations were classified as 'adapted' (A). Second, all were classified as 'not adapted' (N). The matrixes were summarized for both classifications individually and the results compared with the evaluations based on interpolations and common knowledge, i.e. the adaptation level presented in the results section. This process demonstrated that there was no appreciable change in the order of precedence for different levels of adaptation. The 'economic efficiency' and 'utilities' clusters contained the most cases with no documented references (29 and

26% respectively), indicating a greater uncertainty associated with their results compared to the 'amenities' and 'conservation' clusters.

Allocating only three levels of suitability limited the possibility for identifying differences between the practices. For example, clear cutting and irregular shelter were both classed as suitable for game production, but to what extent was not indicated by the model. A narrower categorisation would have produced results that were more detailed, but this was not possible using the literature available.

Matrixes tend to be schematic and do not always reflect reality: all variables cannot be represented in a 'square' in which simplifications and generalisations are necessary. For example, no thinning on a very fertile soil may cause self-thinning, which would make that practice unsuitable for creating a liquidity reserve; however, on poor sites with low tree density, creating a liquidity reserve without thinning is possible. To take such variation into account would require several matrixes with various site indexes. In addition, each practice could be conducted in different ways. For example, if all young trees were removed during cleaning or burning, the practice would be well adapted to culture conservation; however, this would require annual cleaning and thus it would deviate from the definition of a forestry practice. Each objective has a different degree of importance for a forest owner; these could not be considered during the summation of objectives within the clusters. The matrixes provided a systematic and theoretical means of describing a problem, for example allocating an index even where there is a lack of information. An alternative method would have been to evaluate the practices by means of case studies of well-defined compartments and categories of forest owners. This would have been advantageous in that there would be precise descriptions for each compartment and of the preferences of each category of owner, but the lack of literature would remain.

Applications

A time frame of twenty years for the analysis also influenced the results: this is a short period for changes within the forest. However, analyses over a longer period demand consideration of complete silvicultural systems, which was not the aim of the study. Despite the limitations, it is necessary to begin at the stand level in order to evaluate different systems, *e.g.* clear cutting and selection systems.

The technique might be applied where a forest owner, with a definite profile, requests an evaluation of a complete silvicultural system for a compartment over a whole rotation period. Below is an example where a forest owner with an ecological and nature-oriented profile might leave the compartment free to be influenced by natural processes. This hypothetical owner is interested in studying how the practices affect nature and water/soil conservation, in collecting edible mushrooms, in encouraging game and in tax planning. In Alternative 1 (Table 6), the owner chose to avoid active management during the whole rotation and to employ burning. In Alternative 2, a more active and traditional strategy was chosen.

Table 6. Two examples of interactions between several practices in systems (Scores from Tables 1-2)

Alternative 1.	Nature conservation	Water/Soil conservation	Mushroom production	Game production	Tax planning	Sum
No felling	0	0	1	-1	0	
Burning	1	0	0	1	1	
No cleaning	0	0	1	1	1	
No thinning	0	0	1	-1	0	
Sum	1	0	3	0	2	6
Alternative 2.						
Clear cutting	0	-1	-1	1	1	
Planting	0	1	0	1	1	
Cleaning	0	1	1	0	1	
Thinning	0	1	1	1	1	
Sum	0	2	1	3	4	10

Alternative 1 appears inferior in all aspects except for the production of edible mushrooms. The first alternative was, perhaps, extreme, but the example demonstrates that it is possible to examine the suitability of a large number of different silvicultural systems with a range of objectives. In practice, a forest owner could find, for example, that 'nature conservation' and 'mushroom production' were twice as important as the other objectives. The relative positions could be taken into consideration by allocating higher scores, perhaps double those for other objectives, to the most important ones. This would make the two alternatives in Table 6 equally valuable. Thus it is possible to adapt the choice of practices to the different relative importance of the objectives.

An evaluation at stand level may not provide sufficient information for decision-making at the estate level. The composition of the stands, their structure and prior tending, all influence the outcome of favourable practices at the estate level. A complete evaluation of the optimal choices of practices for a large number of compartments at estate level would be complex, especially if it is extended to encompass a whole rotation. Furthermore, in practice the forest owner may pursue different objectives in different parts of the estate. A computerised system would facilitate the right choice of practice and could be used to consider the relative importance of the objectives to the individual forest owner.

Conclusions

Thinning appears to be the most useful forestry practice for small-scale forest owners. Different forms of natural regeneration and cleaning are also appropriate. Passive practices seem to be unsuitable for the multiple objectives of forest owners. The silvicultural practices examined here were not well adapted to conservation. The results indicate that the practices evaluated provide opportunities for forest owners to adapt their forestry to multipurpose objectives. The matrix system could be computerised, but for it to function efficiently it is important to continue to add supporting evidence, especially concerning practices different to those commonly used in Scandinavia. Although the results are essentially restricted to Sweden, the method for evaluating the results of research within the field may have broader applications for the forestry sector in general. The relationship between forestry practices and objectives in general requires further study, for example with respect to liquidity reserve, tax planning, silvicultural challenges and berry and mushroom production.

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