Non-industrial Private Forest Owners' Management Decisions

What affects them and why?

Mats Andersson
Faculty of Forest Sciences
Department of Forest Economics
Umeå

Doctoral Thesis
Swedish University of Agricultural Sciences
Umeå 2010

Acta Universitatis agriculturae Sueciae
2010:57

ISSN 1652-6880
ISBN 978-91-576-7470-8

Print: Arkitektkopia 2010

Non-industrial Private Forest Owners' Management Decisions What affects them and why?

Abstract
This thesis addresses the question of whether and how owner and property characteristics of non-industrial private forest (NIPF) owners affect their attitude toward a financial risk and if the attitude toward risk affects the harvesting decisions and discusses differences in attitude toward risk from a gender perspective. Further, the thesis investigates the owner and property characteristics' effects on objectives of ownership The hypothesis tested here, that the owner and property characteristics affects the attitude toward risk and objectives are largely based on data gathered through a mail survey to NIPF owners in two counties in Northern Sweden.

The results reveal that owner and property characteristic affects the formation of the NIPF owners' attitude toward risk and also their objectives of ownership. The result revealed that NIPF owners vary to a large extent in the subjective judgements that they do about the expected returns from a mature forest stand as compared to investment alternatives outside forestry. This is also true for their judgements about the risk. The analysis further revealed that the preference for risk had a significant impact on the decision to conduct final felling. The NIPF owners who indicated that they were neutral towards the financial risk taking were more likely to have conducted final felling than those averse to the risk and those that indicated that they were risk seeking were even more likely to have conducted felling However, there are also indications that the NIPF owners might have difficulties in incorporating considerations about risk into their forest management planning.

The results of this thesis can be used to further understand previous findings about relationships between owner and property characteristics of NIPF owners and their management decisions. The study points to important links between the owner and his or her decisions. These underlying mechanisms are important knowledge if the aim is to understand the management decisions made by NIPF owners.

Keywords: Non-industrial, Forest, Characteristics, Risk attitude, Objectives

Author's address: Mats Andersson, SLU, Department of Forest Economics,
SE-901 83 Umeå, Sweden
E-mail: Mats.Andersson@sekon.slu.se

Contents

List of Publications

This thesis is based on the work described in the following papers, which are referred to by the corresponding Roman numerals in the text:

I Andersson, M. and Gong, P. (2010). Risk-preferences, risk perceptions and timber harvest decisions – An empirical study of nonindustrial private forest owners in northern Sweden. *Forest Policy and Economics* 12(5), 330-339.

II Andersson, M. (2010). Do owner and property characteristics affect non-industrial private forest owners' attitudes to risk? (*Manuscript).*

III Andersson, M., Hakansson, C. and Holmgren, L. (2010). Non-industrial private forest owners' financial risk taking – Does gender matter? *Scandinavian Journal of Forest Research. In print*.

IV Andersson, M. Effects of owner and property characteristics on non-industrial private forest owners' objectives (manuscript).

Papers I and III are reproduced with the permission of the publishers.

1 Introduction

Forests are important renewable natural resources that have value to most societies around the globe. Forests provide many different products and services. A major example of the products is timber, which is used as fuel wood, or as raw material in sawmills and pulp mills. Further, forests provide many non-timber products, such as fodder, berries, mushrooms, nuts and rubber. Examples of services provided by forests are water purification, carbon sequestration, biodiversity conservation, recreation opportunities and protection against erosion, and so on. Some of the products and services can only be legally exploited by the owner of the forest, while other products and services may be extracted, used or enjoyed by others too. For instance, in most parts of the world timber can only be legally harvested at the initiative of the owner of a forest, while recreational services can often be enjoyed by people other than the owner, especially those living in the vicinity of the forest. The services of maintaining biodiversity and carbon sequestration may, in principle, be enjoyed by people all over the planet. Hence, the ways in which forests are managed can have profound impacts both locally and globally.

In Sweden, as in most parts of the world, the use of the forest has a very long history. Humans used wood from the forest to make fire in far-distant, pre-historic times and since then wood has been used for: construction; making furniture, tools, tar, potassium carbonate and saltpetre; and as fuel in both household and industrial production processes, e.g. iron-making, and in sawmills and pulp industries (Mattsson and Stridsberg, 1981). In addition to wood, forests have offered opportunities for hunting game, picking berries and

mushrooms, and other activities. Most of the goods and services that the forests have offered historically are still valuable today.

Sweden has about 23 million hectares[i] of forestland (Skogsstyrelsen, 2009); more than 55 % of the total land area in the country. Following rapid growth of the saw and pulp mill industries in the middle of the 19th century, the pre-dominant use of the Swedish forests has been as a provider of inputs to those industries. There is no doubt that the forest sector has been, and still is, important to the Swedish economy; for example, the value of exports of forestry and forest products from Sweden amounted to 122 billion Swedish crowns in 2006, which is 11.2 % of the total value of export goods and 4.2 % of GDP (Skogsstyrelsen, 2009). Furthermore, although the forest sector have become a highly mechanised industrial sector through a series of modernisations, and hence have employed steadily fewer people, it still employed approximately 100,000 persons, corresponding to 2.2 % of the total workforce in Sweden, in 2008 (SCB, 2010).

From a global perspective, there are differences among nations in forest ownership structure. In some countries, large parts of the forests are owned by the state, while in others, such as the Nordic countries, most of the forests are owned either by large forest companies or so-called non-industrial private forest (NIPF) owners. NIPF ownership is characterised by one or a small number of individuals privately owning a forest property[ii]. Of the 23 million hectares of forestland in Sweden, 50 % is non-industrial private forestland (Skogsstyrelsen, 2009), and in total there are around 329,000 NIPF owners in Sweden today (Skogsstyrelsen, 2009).

The largest proportions of NIPF lands are located in southern Sweden and coastal areas. These areas are in the most productive climate zones, thus the non-industrial private forests are on average more productive, in terms of biomass, than forests in other ownership categories. According to calculations by the Swedish Forest Agency, annual harvests in non-industrial private forests accounted for 63.8% of the total volume of gross timber harvested in Sweden during the period 2005-2007 (Skogsstyrelsen, 2009).

The decisions that forest owners make regarding the management of their forests are not important only for themselves. The forest conditions and the flow of goods and services also affect others in society, as mentioned above. This is true for all forest owners, including NIPF owners. The management decisions taken by the NIPF owners are especially interesting, since they are known to have a

diverse set of ownership objectives, as well as varying substantially in knowledge and engagement in forestry. In cases where they own large areas of forests, as in Sweden, the potential impact of their actions is also particularly large, providing strong reasons for studying their motivations and management decisions. Although NIPF owners generally capture only part of the total value of the goods and services produced in their forests, they bear the major part of the production costs. The private forest owners deliver goods and services to society for which they are not (fully) paid, often leading to underproduction of such goods. Kriström and Skånberg (2001) roughly estimated the values of all the goods and services from the Swedish forests, and found the sum annual value of recreation, erosion protection and carbon sequestration services to be similar to the value of the annual output of wood from the forests. On the other hand, since society does not fully compensate the NIPF owners for all the goods and services provided, the forest management decisions made by individual forest owners are not likely to be optimal from society's perspective. A socially optimal management of nonindustrial private forests would be a maximization of the sum of net benefits.

Due to the importance of forests as providers of goods and services, there have been intensive attempts to predict the behaviour of NIPF owners, and to relate NIPF owners' personal and property characteristics to their management decisions, especially their decisions concerning timber harvesting. Such research links owners' property and personal characteristics directly to their behaviour. From such studies it is known (*inter alia*) that the age of the NIPF owner, his/her exogenous income and the size of his/her forest property are important determinants of harvesting decisions, see e.g. Beach et al. (2005) or Amacher et al. (2003) for reviews of studies of NIPF owner behaviour.

The fact that forest owners' personal characteristics affect their management decision indicates that forest owners' valuation and judgements play an important role in forestry decision making. In order to achieve a better understanding of the behaviour of NIPF owner, it will be useful to include their preferences and objectives into the analysis. On the other hand, while owner and property characteristics and harvesting decisions are fairly easy to observe empirically, the inclusion of objectives and preferences adds a dimension that is not readily observable, and thus demands more effort from the researcher. In this thesis, the term "objective" broadly

covers all the objectives that a NIPF owner might have, and they are explored through analyses of statements about intentions or descriptions of the goals of NIPF owners. As illustrated in Figure 1, the objectives and preferences of each forest owner (the decision-maker) (and decision alternatives available to them) are affected by numerous factors, including their personal characteristics and those of their forest resources, in addition to their perceptions and judgements.

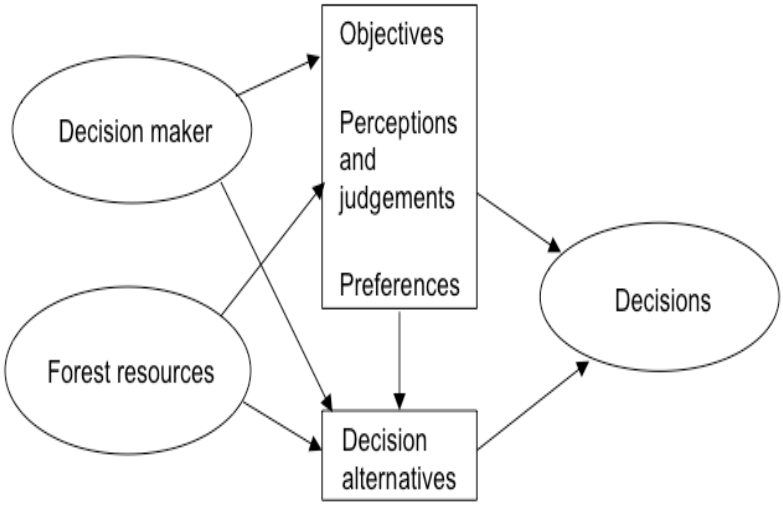

Figure 1. Factors affecting NIPF owners' decision-making.

Adding uncertainty and risk to decision problems add more complexity to them. However, it is important to consider uncertainty when addressing decision problems involving the future, since the only thing we really know about the future is that it is uncertain. When uncertainty is considered, an important issue is the effects of different attitudes to risk. People vary in their willingness to expose themselves to risks. Some people have a gambling attitude and are willing to put assets at stake even if the chances for gains are small, while others like to play safe and even reject investments when the chances of gains are very good. The terms used to describe risk preference used in this thesis, and the underlying studies (*willingness to take risk* or *attitude to risk*) have been deliberately chosen to allow both risk-averse and risk-

seeking attitudes to be expressed, and their effects to be explored. Much of the literature deals with risk-averse decision makers. Pioneering advances that facilitated the measurement and theoretical understanding of risk aversion were the von Neumann-Morgenstern theory of expected utility (von Neumann and Morgenstern, 1944), further developed by Friedman and Savage (1948) and the Arrow-Pratt measures of risk aversion (Pratt, 1964; Arrow, 1965).

In conjunction with the many possible objectives of ownership of NIPF owners, the willingness to take risk also has the potential to affect their management decisions. It has been shown theoretically by, for instance Gong and Löfgren (2003) and Ollikainen (1993), how NIPF owners can be expected to adjust their timber harvests in response to variations in risk and risk aversion. It is generally concluded, as in Clarke and Reed (1989), that the optimal cutting age is lower for the risk-averse owner than for the risk-neutral owner. To clarify the concepts of risk and uncertainty, risk is present when a venture has more than one possible outcome and the probabilities of each quantifiable outcome are known, while uncertainty is present when various possible outcomes of a venture are known, but not their probabilities. There is however reason to recognize that in real life situations, it is very uncommon that one in fact know the exact probabilities of different outcomes. Such recognition has lead to a situation where the two terms have been used in an interchangeable way. In this thesis too, the two terms are used interchangeably.

Although previous research on NIPF owners' behaviour has provided much valuable knowledge, there are still gaps in our knowledge that warrant further research. There is for instance not enough knowledge about the underlying mechanisms through which the owner and property characteristics influences the management decisions of the forest owner. The characteristics influence the objectives, e.g. to what extent timber production is prioritized, the preferences, e.g. whether the financial risk in forestry investments are desirable or not, but more knowledge is needed about the mechanisms through which characteristics exert their influence on the decisions. Further, although many theoretical analyses have shown how NIPF owners with different preferences can be expected to behave under different risk scenarios, more knowledge is needed about whether differences in observed behaviour can be attributed to different risk preferences.

The ownership structure of the NIPFs is not constant over time, and the variations may have strong effects on how the forests are managed and utilised. Neither socio-economic factors describing the NIPF owners, nor the boundaries of the forest estates, are constant over time. For instance, as a forest owner ages his or her objectives, preferences and management decisions may change. Eventually, the forest estate might be bequeathed, which might mean a change from single ownership to multiple-ownership or perhaps a split of the property into two or more smaller properties. Another ongoing change in the ownership structure of NIPFs is that the proportion of female owners is increasing. Between 1976 and 2008 the proportion of female owners rose from around 20 % to 38 % (Lidestav, 1998; Skogsstyrelsen, 2009). In Sweden, as in many other countries, another relevant factor is ongoing urbanization, resulting in an increasing proportion of forest owners living far from their forest properties. This also affects their goals and motivations. For instance, Berlin et al. (2006) found significant differences between the values appreciated by resident owners and non-resident owners, as well as between members and non-members of NIPF owner associations. As demographics of NIPF owners and the ownership structure of private forests keep evolving, there is also a need to reassess the social optimality of forest policies from time to time. This is facilitated by knowledge about the underlying mechanisms whereby objectives and preferences are formed. It will always be easier, and hence less costly, to monitor trends in demographics and ownership structures than to monitor objectives, judgements and preferences. Therefore, we frequently use these more easily accessible characteristics of individuals and their assets. However, knowledge about the underlying mechanisms whereby the characteristics, as elements of a wider context, influence decision-making is essential for a deeper and more complete understanding of the motivations (and hence decisions) of NIPF owners.

It should be emphasised that directly relating characteristics to objectives, preferences or behaviour is a simplification. The inter-related factors and circumstances that determine individuals' behaviour are too complex to fully map by simply studying characteristics. In real life there might even be factors, such as mood at a certain time, that affect decision makers even when making quite important decisions. Thus, we often have to use an easily observable feature, although it might poorly, or uncertainly, reflect factors that

really affect people's behaviour. One such example is the relationship between sex and gender. Biological sex is an easily observable characteristic that is sometimes included in analyses of NIPF owners' behaviour. In such cases significant behavioural differences between men and women are often found. One might wonder why that is, but in most such cases no questions are asked about the reasons for the differences in behaviour. May females, for instance, be less interested in making money simply because of their biological sex? Perhaps our understanding would benefit if we considered differences between men and women more deeply, and included the social and cultural context in which they are situated. Such an approach would mean dealing with gender issues rather than the easily observable biological sex of owners. Of course, this would further add to the difficulty of observing features that we would need to observe.

In studies such as those appended to this thesis, the use of owner- and property characteristics should be seen as approximate representations of the overall qualities of unique individuals.

2 Objectives and main contribution

The overall aim of the studies this thesis is based upon was to acquire new knowledge and better understanding of Swedish NIPF owners' management decisions. A specific goal was to increase understanding of the mechanisms whereby owner and property characteristics affect the choice of management activities. To this end a major concern was to explore the correlations among owners and property characteristics, their objectives of ownership and attitudes to risk, and hence address the hypothesis that effects of owners and property characteristics on their objectives and attitudes explain the effects of those characteristics on management decisions. This is the reason for including the question "why?" in the sub-title of the. It is beyond the scope of this thesis to answer the next apparent question; why do characteristics affect risk attitudes?

Another aim of this thesis is to investigate NIPF owners' knowledge of their preferences and to what extent they are capable of making consistent choices in the context of forestry decision making under conditions of risk. Further, the potential to improve the understanding of NIPF owners' behaviour from including discussions of social and cultural contexts, such as gender, will be discussed.

The main contributions of studies are:

- They have illustrated how NIPF owners' attitudes to risk can be elucidated, and how such attitudes can be included in empirical studies of NIPF owners, by considering responses to survey questions regarding a hypothetical timber sales contract.

- They show that NIPF owners' attitudes to risk affect

their management decisions and provide information about those effects. NIPF owners' judgments about the risks of alternative investments, which are needed to explain an observed behaviour, are also investigated.

- They show that NIPF owners' owner and property characteristics affect their attitudes to risk and provide a way of empirically establishing relationships between the characteristics and the attitudes.

- They show that individual owner and property characteristics can be used as explanatory variables for individual ownership objectives and how a set of characteristics affects the objectives.

Taken together, the knowledge contributed by the studies provides a new dimension of knowledge about NIPF owners and should be useful for developing more detailed knowledge in the future. The findings will be useful both for predicting NIPF owners' management decisions, such as their timber supply, and for policy development.

3 Literature overview

3.1 Theoretical studies

One way of structuring research on optimal management of forests is to divide the research into optimal rotation models and two-period, or household production models.

A classical paper in the optimal rotation framework is the one by the German civil servant Martin Faustmann, who addressed the problem of when to cut a forest stand down. In 1849, Faustmann published a widely used formula formula for calculation of the value of a piece of land devoted to timber production for repeated rotations (Faustmann, 1849). The optimal rotation problem has been addressed in numerous studies since Faustmann's famous article was published, but it still has a place in forest economics.

The other frequently used framework in the modelling of NIPF owners' management is the household production model, where a two-period or a multi-period framework is used. Under certain assumptions both in the optimal rotation framework and the two-period framework decisions about the production of goods and the consumption of the goods can be separately considered. The assumptions enabling such separability include (*inter alia*) that capital and timber markets are perfect, model parameters are certain, and decision-makers do not value non-timber benefits. Separability has been demonstrated for the rotation framework by Samuelson (1976) and for the two-period framework by Koskela (1989).

In the decades that have passed since Faustmann's article was published, various researchers have wanted to include other factors affecting the optimal use of forests in models, such as amenities, uncertainties (in prices, in interest rates and in timber growth etc.)

and different preferences of the decision-makers. For this purpose, both the optimal rotation framework and the two-period framework have pros and cons.

The problem of identifying the optimal forest rotation has been extended to include non-timber products and services. One of the first optimal rotation models to include non-timber benefits is that by Hartman (1976). He included the benefits of what he called recreational values, a generally used term that can include any valued benefits from the forests in addition to timber production. Another example of a model for obtaining the optimal rotation length for an even-aged forest stand that considers non-timber benefits is that of Strang (1983). Tahvonen and Salo (1999) presented a more detailed analysis of the effects of including non-timber amenities in the optimal rotation problem. Solving the optimal rotation problem normally produces an optimality condition, which states that the forest stand should be harvested at an age at which the marginal benefit equals the marginal cost of postponing harvest. With the inclusion of the non-timber benefits it has been shown that the optimal rotation length can change in either direction, and the optimal decision might even be to never cut the stand.

Most optimal rotation models are single-stand models, a drawback of which is their neglect of the interdependence of adjacent stands. Clearly, the loss of non-timber values when a stand is harvested is dependent on the adjacent stands' abilities to provide the same non-timber benefits. This issue has been addressed in the optimal rotation framework by, for instance, Swallow and Wear (1993). Standard optimal rotation models generally assume that the social economic conditions are constant over time. Non-constant conditions call for dynamic models, and could (for instance) include the possibility that land use or production functions may change over time.

The other frequently used framework in the modelling of NIPF owners' management decisions, the household production model framework, can be designed to allow for non-constant social economic conditions. Basically, according to household production models, the owner receives utility from the consumption of both timber revenues, income from exogenous sources and (typically) from consumption of non-timber products and services. Prices, interest rates, taxes etc. are allowed to vary over time.

These types of models also offer the possibility to include intertemporal aspects of preferences for consumption. In the

household production approach it is possible to model the trade-offs between decisions to harvest (and obtain income for consumption) and use other, exogenous sources of income for consumption while also recognizing the utilities from consumption of non-timber benefits. Application of the two-period framework clearly shows that if the decision-maker values non-timber amenities provided by the standing forest, or if uncertainties are included, the separability, as shown by e.g. Koskela (1989), no longer holds. In such a situation the decisions will also depend upon the specific preferences of the decision maker.

Authors who have developed and applied household production functions to private forestry decisions, include Binkley (1981), Max and Lehman (1988) Dennis (1989), Johansson and Löfgren (1985), Kuuluvainen (1990), Kuuluvainen and Tahvonen (1999), Bolkesjo and Baardsen (2002).

A general conclusion that can be drawn from the theoretical analyses in this type of study, regardless of the non-timber benefits included, is that the forest owner should harvest up to a level where the utility from additional harvest income equals the utility of the non-timber benefits that must be foregone to obtain that marginal timber income. Another common finding of theoretical analyses based on the household production models is an ambiguous effect of an increase in the timber price because of the opposing income and substitution effects. An increase in timber price would induce the forest owner to harvest more, but the increased timber price also means increased forest owner wealth, which could increase his or her demand for non-timber goods and thereby reduce harvesting.

There is also a type of model that is a mixture of the optimal rotation and the household production types, called transition models. Such models incorporate an initial period of dynamic rotationis before the rotation age stabilizes, see e.g. Newman et al. (1985).

In most of the theoretical studies discussed above it is assumed that future prices and forest stand developments are deterministic. Other models have been suggested to incorporate (some of) the uncertainties associated with future events. Most of these models focus on uncertainty in future timber prices but some also include stochastic components of for instance timber growth or interest rates.

Studies of the optimal rotation type that deal with uncertainties include those of Norstrom (1975), Reed (1984), Lohmander (1987), Brazee and Mendelsohn (1988), Gong (1999) and Gong et al. (2005). The models presented in these studies can also be described as

adaptive models, since the decision-maker is assumed to continuously monitor the state of the model parameters and decide whether to harvest immediately or wait with harvesting. In particular, it has been shown that under conditions of uncertainty in timber prices, the reservation price strategy leads to higher expected returns than harvesting at a fixed age.

When decisions are made under conditions of uncertainty, a further complicating factor is that all decision makers do not have the same willingness to be exposed to risks. Risk aversion has been considered, instead of assuming that decision-makers are risk-neutral, in several studies. The risk-averse decision-makers have an increasing utility of wealth, but it increases at a decreasing rate. Examples of such studies, in which the optimal rotation framework was used, include those of Clarke and Reed (1989) and Alvarez and Koskela (2006), and Gong and Löfgren (2008). Clarke and Reed (1989) studied the optimal rotation under conditions of timber price uncertainty, uncertainty in the growth of the biological asset, and risk aversion. Another study dealing with timber price uncertainty and risk aversion in the optimal rotation framework is that of Gong (1998). Alvarez and Koskela (2006) studied the optimal rotation assuming interest rate uncertainty and risk aversion.

A two-period approach when studying risk aversion might be appealing, since it allows a relatively simple differentiation into a certain first period and an uncertain second period. Amongst other factors, the decision-maker's degree of risk aversion will determine the allocation of harvests between the first and second periods. The two-period approach to studying effects of uncertainty and risk aversion was applied by Johansson and Löfgren (1985), who found that under uncertainty in the second period price, the risk-averting forest owner will harvest more in the first period and less in the second period, compared to a risk-neutral owner. Ollikainen (1990) studied the effects of interest rate uncertainty using the two-period framework. Koskela and Ollikainen (1997) examined optimal forest taxation in the two-period framework, assuming variations in risk aversion, timber price uncertainty and that the forest owners value amenity services in addition to timber production.

Other examples of forestry decision models in which the two-period approach has been applied to include risk preferences are those presented by Ollikainen (1991), Uusivuouri (2002) and Gong and Löfgren (2003). A common result of such studies is that timber

harvesting will be advanced following increases in either the probability of an undesirable event, e.g. forest fire, or aversion to risk.

In analogy with the opposing income and substitution effects on harvesting of increases in timber price, there might also be an ambiguous effect on first period harvesting due to the effect of increased wealth on the degree of risk tolerance. This effect is dependent on the assumptions made about the properties of the risk aversion, as discussed (for instance) by Johansson and Löfgren (1985) under the assumption that the forest owner has decreasing absolute risk aversion. With such an assumption, an increase in the price during the first period will, via the substitution effect, increase the first period harvest, but the increased first period wealth induces the forest owner to take more risks, which encourages the owner to postpone harvests to the second period.

3.2 Empirical studies

3.2.1 Optimal decisions

Authors who have considered the optimal rotation length of a forest stand include Calish et al. (1978), who used the Hartman model to calculate the optimal rotation for joint production of timber and non-timber benefits. The cited authors concluded that the optimal rotation period is only changed marginally, but the period may be either shortened or prolonged when the non-timber benefits are considered. Englin (1990), like Calish et al. (1978), realized the difficulties of using a single function to describe all of the non-timber benefits. His empirical approach focused on the amenity values stemming from overnight hiking and how the valuations of overnight hiking parties could affect the optimal rotation period for a single stand. Englin (1990) found that the recreational values of overnight hiking (which, as pointed out by Englin, is just one of many potential non-timber benefits from a forest stand) are substantial. A study by Huang and Kronrad (2006) considered the effects of including the benefit of carbon sequestration on the optimal rotation and profitability of loblolly pine plantations. Their results show that the optimal rotation may vary, depending on site quality and the owner's alternative rates of return.

3.2.2 Econometric studies of behaviour

As described by Wear and Parks (1994), the household production framework "has the potential to provide insights into the provision of wood products from a forested landscape with variable forest ownership characteristics and variable forest conditions". Many of the published empirical studies on how owner and property characteristics affect NIPF owners' decisions are from North America or the Nordic countries, since these areas have large proportions of NIPF ownership. In these studies it has often been found that the size of the productive land is a property characteristic that strongly affects the behaviour of NIPF owners, in various countries, for instance North America (Binkley 1981; Conway et al. 2003), Finland (Kuuluvainen et al. 1996) and Sweden (Carlén 1990). Increases in the area of forestland generally increase the probability that the forest owner will have conducted timber harvests or other silvicultural activities during a given survey period. The site quality and/or timber stock are other property characteristics that are positively correlated to the propensity of harvests and/or other silvicultural activities (Carlén, 1990; Bolkesjö et al., 2002; Löyland et al., 1995; Dennis, 1989).

Turning to owner characteristics, the NIPF owner's age has been found to affect management decisions. Conway et al. (2003) found that increasing age of the owner had a positive effect on the probability that he or she would harvest timber. This age effect is contrary to the results of many other studies (e.g. Kuuluvainen 1989; Carlén 1990; Lidestav and Ekström 2000), where age was found to have a negative effect on the probability of conducting harvest. Age has also been found to have a negative effect on the level of harvests (Bolkesjö et al., 2007; Favada et al., 2009). Another characteristic that seems to affect behaviour is the owner's sex. Lidestav and Ekström (2000) found that male forest owners were more likely than female counterparts to engage in timber harvesting and other silvicultural activities. Conway et al. (2003) further found that owners residing elsewhere rather than on their NIPF property, so-called absentee owners, were less likely to engage in silvicultural activities than resident owners. Similar results were found by Romm et al. (1987) and Löyland et al. (1995) in studies of Californian and Norwegian NIPF owners, respectively. Vokoun et al. (2006) used a multiple bounded discrete choice approach, in which NIPF owners in Virginia were asked about their lowest acceptable price for a hypothetical harvest, and how much (in percent) of the hypothetical stand they would harvest at that price. Their empirical

investigation, although based on stated rather than observed behaviour, is an extended version of a reservation price strategy study that enables the inclusion of owners who have chosen not to harvest timber given the current market timber price. Vokoun et al. (2006) found (*inter alia*) that absentee owners are less likely to harvest all of a hypothetical stand compared to non-absentee owners and that the length of ownership increases the probability that the owner will choose the harvest-all alternative.

3.2.3 NIPF owner typologies

As mentioned above, the effects of objectives and preferences in the chain from characteristics to decisions have also been considered by some authors, e.g. Kurtz and Lewis (1981), who used a psychological testing technique, and divided a sample of NIPF owners into four typological groups. For a sample of Finnish NIPF owners, Kuuluvainen et al. (1996) formed a typology of four groups and studied their objectives in relation to harvesting intensity. For Swedish NIPF owners, Ingemarson et al. (2006) grouped respondents into four classes based on their objectives. The results show that increasing the area of productive forestland increases the probability that the NIPF owner has an economic objective of ownership. Older NIPF owners are also less inclined to have conservational objectives, compared to younger owners. A review of studies on NIPF owner typologies has been presented by Ní Dhubáin et al. (2007).

3.2.4 Non-timber benefit valuation

There have been numerous studies of the valuation of non-timber benefits by different groups in society, but very few on the forest owners' valuations of these benefits. Scarpa et al. (2000) used the contingent valuation method to assess how much visitors to public forests in Ireland are willing to pay for forest attributes. The results indicate that nature reserves are highly valued and that establishing nature reserves on forest sites where there are none would be highly beneficial. Strange et al. (1999) used a linear programming approach and the travel cost method (TCM, which is used to obtain willingness to pay-measures for recreational benefits) to obtain estimates of the monetary value of the non-timber benefits of public forests in Poland. Their results confirm that the inclusion of various non-timber benefits

results in optimal management decisions that are substantially different from those for a purely commercial forest. One example from Sweden was provided by Mattsson and Li (1994), who asked respondents to look at pictures of forest stands in different development stages (and managed with different silvicultural methods) then asked them how much they would be willing to pay for experiencing the non-timber benefits. They found the mean willingness to pay for this experience was 2195 SEK per year

While the studies mentioned above concern the valuations people generally make, Raunikar and Buongiorno (2006) estimated NIPF owners' willingness to pay for natural forest stands by comparing the profits of managing mixed loblolly pine hardwood forest stands as "natural stands" to those of managing the stands as plantations. They concluded that their result (a willingness to pay $149/ha/year) was a lower bound of the NIPF owners' willingness to pay for forest amenities.

An overall conclusion that can be drawn from published valuation studies of non-timber benefits is that these values in aggregation are substantial, and if correctly accounted for they should have a major impact on management decisions.

Before turning to how NIPF owners value the risks in forestry it should be noted that in this thesis (and the underlying studies) only the financial risk is considered. The finacial risk originates from uncertainty in the future timber price. Previous studies of NIPF owners and their perceptions of and attitudes to risk indicate that financial risks are considered to be more important than risks of, for instance, wind throw, root rot or insect damage (Lönnstedt and Svensson, 2000; Blennow and Sallnäs, 2002; Stordal et al., 2007). Lönnstedt and Svensson (2000) found that attitudes to risk-taking were dependent on the forest owners' farming/forestry activity, and hence his or her familiarity with the forest as a resource. Blennow and Sallnäs (2002) concluded that there is a high willingness to avoid many of the risks in forestry, but also that there is a high proportion of NIPF owners who do not know whether they take risk-reducing measures or not, which the authors concluded is a clear sign of risk-taking behaviour.

4 Methods

4.1.1 Hypothesis

From the literature overview of the previous section it should be clear that the owner and property characteristics affect NIPF owners' objectives of ownership as well as their management decisions. It should also be clear that the inclusion of uncertainties, or risk, and how it is included, have great potential to affect the outcome of an analysis of NIPF owner behaviour. From the typology studies and the non-timber valuation studies we also know that the forest owners have a rich set of objectives and that forests provide many different and valuable functions.

The main hypotheses addressed in the studies that this thesis are based upon were that owner and property characteristics influence management decisions mainly through their impacts on NIPF owners' objectives of ownership and their attitudes to risk, and through their impacts on NIPF owners' judgements concerning the risks in alternative investments. It should therefore be possible to establish measurable relationships between owner and property characteristics and the two dependent variable categories. The hypotheses were tested using data on NIPF owners and their properties, and regression models to identify characteristics that influence their objectives and risk attitudes, and how this influence is manifested. Further, it was (and is) recognized that relating observable characteristics to decisions is a simplification, and the possibility that less readily observable factors, such as gender structures, may also be influential was considered. The consistency of statements concerning attitudes to risk

was investigated using responses to hypothetical questions regarding the NIPF owners' willingness to take a financial risk in forestry.

4.1.2 The area studied

The data used in the studies were gathered through a survey, sent by mail, to owners of NIPF properties in two counties in northern Sweden (Västerbotten and Västernorrland, for locations, see figure 2). These counties are both located in a region where forestland is relatively abundant and forestry is considered an important activity for regional welfare[iii]. In Västerbotten there are around 24,000 non-industrial private forest owners, around 19,600 NIPF management units[iv] and 44 % of the forestland is owned by NIPF owners. In Västernorrland there are around 16,900 NIPF owners, around 13,900 NIPF management units and 42.5 % of the forestland is owned by NIPF owners (Skogsstyrelsen, 2009).

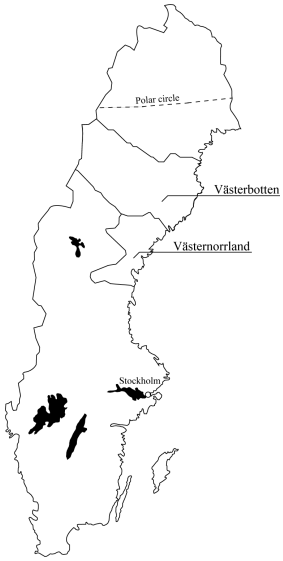

Figure 2. Map of Sweden showing the studied counties.

The total area of forestland in the two counties is nearly 5 million hectares, accounting for 21.3 % of all forestland in Sweden.

Conifer forests dominate the area and although their growth is relatively slow, the NIPF owners in the area are important providers of

raw materials for various wood-based industries. Both counties are located in the boreal zone (Ahti et al., 1968) and are bordered to the east by the Baltic Sea. However, their western borders are different; Västerbotten extends all the way to the Norwegian border in the west, while Västernorrland extends roughly half as far to the west, see Figure 2. This geographical area was selected for study since there had been a lack of studies of NIPF owners and their management decisions in the area, and I was familiar with NIPF ownership in this area, since it might be advantageous to have some prior knowledge of the study subject.

4.1.3 Data

Addresses for 1000 randomly chosen owners[v] of forest estates with a productive land area of 25 hectare or more in each county were obtained from the Forestry Board (Skogsstyrelsen). NIPF owners with forest properties covering less than 25 hectares were excluded, because small forest properties are regarded as having very little economic significance for their owners, and the general interest was in economic aspects and decision-making. The questionnaire, translated into English, is appended to this thesis. The survey received a total of 1,052 usable responses, equivalent to a response rate of 52.6 %. Some descriptive statistics of the respondents are given in Table 1.

Table 1. *Descriptive statistics of the respondents.*

	Västerbotten	Västernorrland	Total
Response rate (%)	54.7	50.5	52.6
Share of females (%)	25.0*	34.6*	29.6
Mean age (years)	59.7	59.1	59.4
Number of persons in household[a]/persons younger than 20 years	2.4/0.49	2.4/0.49	2.4 /0.49
Length of ownership (years)	24.1	21.9	23.0
Number of owners	1.7*	2.2*	2.0
Membership of NIPF owner association (%)	55.3*	68.2*	61.5
Home (permanent or leisure) on property (%)	78.6	75.4	77.1

* Indicates that the difference between the two counties is statistically significant at the 5 % probability level.

[a] Households with more than five persons were counted as having five persons.

The questionnaire was designed to provide information about owner characteristics, property characteristics, objectives of ownership, some recent activities carried out in the forest, the respondent's subjective judgements concerning a set of investment alternatives, the respondents' attitude to financial risk-taking in forestry, and some additional issues.

The first part of the questionnaire concerned standard background information, including the importance of any income from forestry, specifically from timber sales, for the NIPF owner's household. This measure was rather rough, with three levels of importance. The survey also provided information on the most important objectives of ownership. The respondents were asked to choose the three objectives of ownership that are most important to them, from a list of eight, with an option to state other, additional objectives. Further, questions about final felling conducted during the previous five years as well as planned felling in the near future were included. The respondents were also asked about how they had invested profits from timber felling and their main reasons for their choices. In addition, the respondents were asked to subjectively assess the risks and returns of alternative investments compared to keeping the capital in the form of mature forest stock.

A central part of the questionnaire concerned the NIPF owners' attitudes to risk, captured by asking each respondent to make a decision regarding a hypothetical problem formulated to reveal risk preference. The respondents were asked to assume it had been decided that a harvest of timber would be done in one year's time, and to state whether he/she would accept or decline a timber sales offer. Accepting meant that the forest owner would receive a fixed price per cubic metre for the harvest that would take place in a year's time, while turning the offer down meant accepting the market price for timber at the time of harvest, which is stochastic. Each respondent was also given information about the range within which the timber price in a year's time would be, and was implicitly informed that the future market price had the same expected value as the current price offer. The respondent's choice did not affect the time when the payment for the harvested timber would be received. The respondent was asked to indicate whether he or she would prefer to accept the price offered today, to reject the price offered today and accept the price that would prevail in a year's time, or whether he or she was indifferent to the two options.

Using the subjective judgments about the financial risks and the expected returns on the alternative investments in comparison to the risks and returns on capital placed in the mature forest, the most preferred investment for each respondent was also defined. However, a preferred investment could not be defined for all respondents, e.g. not those who answered that returns and risk in all investments were considered to be equal.

In addition to the question concerning preference for risk, there was another question that asked the respondent to state an amount that would make the alternative associated with the pre-specified level of risk and a risk-free alternative equally attractive for him or her. The reason for asking this question was that a risk-averse person would be willing to forgo some of the expected income to obtain certainty, while a risk-seeking person would reason in the opposite way.

4.1.4 Method

As described above, the survey elucidated the respondents' willingness to accept a financial risk in a forestry decision. In addition the respondents were asked to state their reservation price for closing a risk-free timber sales contract. By comparing the responses to the former risk attitude question and the latter reservation price question some judgements of the NIPF owners' consistency in statements concerning their risk attitude could be made. Further, by using the stated attitude toward risk, and the judgements of risks and returns in mature forest stands compared to alternative investments, the respondents' preferred investment could be assigned. Harvesting decisions could then be compared for groups of different preferred investments (Paper I).

The formulation of the questions regarding NIPF owners' attitude to risk, and hence the following analyses, was based on the expected utility theory (von Neumann and Morgenstern, 1944). The expected utility theory states that, under certain conditions, a decision-maker's choice among risky or uncertain prospects can be described as an expected utility maximization problem. Analysis of responses to both of the questions used to reveal the NIPF owners' attitude to risk was based on comparing an uncertain value with a known probability distribution to a certainty equivalent. Other approaches than one based on expected utility could have been used, e.g. risk attitudes could have been measured using a psychometric approach or the risk-return

framework. However, since the certainty equivalence format and the expected utility approach are frequently used in studies on risk preferences and, as shown by Pennings and Smidts (2000), the use of certainty equivalence question formats usually leads to reliable results, this approach was considered satisfactory.

For the analysis of how owner and property characteristics influence owners' attitudes to risk, an ordered probit model was used. Based on the attitudes to risk that the respondents revealed through the survey responses they were classified into three categorical groups of risk tolerance: risk-averse, risk-neutral and risk-seeking. A fourth, not insignificant group, comprised those who stated that they could not answer the risk attitude question. How this group was treated is discussed in Paper II.

A model for studying how explanatory variables affect outcomes such as the categorical levels of risk attitudes is preferably able to handle outcomes that are discrete in nature[vi]. The data on risk preference categories obtained from the survey were considered to be of an ordered nature, and such data can be analysed using either an ordered logit model or an ordered probit model. In probit modelling the error terms are assumed to be normally distributed with a zero mean and unit variance, while in logit model the error terms are assumed to be independent, but logistically distributed. Hence, which of those two models should ideally be used is largely dependent on the assumptions made about the error terms. In this case an ordered probit model was chosen, an index was created to indicate the risk preference of each respondent, and this index was assumed to be a function of the owner and property characteristics.

The use of an ordered probit model implies, first, that an individual's risk preference is assumed to lie somewhere on a continuous scale from extremely risk-averse to extremely risk-seeking, which is probably an uncontroversial assumption. In the probit model that was constructed, this continuous scale is divided into intervals, each of which corresponds to one of the index classes averse, neutral or seeking (which were the observable categorical levels in the data). The probit model estimates (by maximum likelihood procedures) the coefficients and cut-off points that, together with the standard normal cumulative distribution function, can be used to compute the probabilities that a NIPF owner belongs to each of the risk preference groups (Paper II).

In paper IV, the information about the objectives of ownership the respondents regarded as most prioritized were used. The objectives were used as dependent variables and the owner and property characteristics as explanatory variables in a set of probit regressions, in which the binary response variable equalled 1 if the owner marked the objective as prioritized, and 0 otherwise. The probability that a respondent had a specific objective was then estimated by maximum likelihood estimation using the constructed probit model, based on a cumulative normal distribution function.

The survey included a list of eight objectives of ownership, from which the respondents were asked to choose the most important (up to three) objectives. The chosen objectives were not ranked, but the objectives chosen were considered to be the respondent's most prioritized objectives. Those who did not find their most important objective in the list could define a further objective themselves. The objectives listed in the survey are presented in Table 2.

Table 2. *The ownership objectives listed in the survey.*

Objective	Abbreviation
Contribution from forestry to the household economy	Economic contribution
To maintain a tradition of forestry within the family/Keeping contact with native locality	Forestry tradition
Access to game hunting opportunity	Hunting
Access to recreation, picking berries or mushrooms	Recreation
Silvicultural work as meaningful leisure time activity	Leisure activity
To maintain nice, aesthetically pleasing surroundings around the house	Aesthetics
To create or maintain a richness of plants and animals	Biodiversity
A large stock of timber in the forest	Timber stock
Others	

The data were used to identify owner and property characteristics that influenced the NIPF owners' choices of prioritised objectives of ownership. For each of the possible objectives, a probit regression model was used, in which the binary response variable equalled 1 if the owner had marked the objective, and 0 otherwise. From the regressions, in which the owner and property characteristics were

explanatory variables the estimated probability that an individual did prioritise the considered objective was obtained from the cumulative distribution function. The parameter estimates of the regressions were obtained by maximum likelihood estimation (Pindyck and Rubinfeld, 1991).

In Paper III, where the finding that women seem to be more risk-seeking than men is discussed in a gender theory framework, a simple statistical analysis was conducted. Starting by simply comparing females' and males' willingness to take financial risk and gradually adding the two layers, dependency of income from forestry and the objective of achieving income from forestry, the reported pattern emerged. The significance of differences between groups was tested using chi-square tests. The results were placed in a gender context largely following a classification presented by Lidestav (2010) of the roles that women recognize they play in intergenerational family forest ownership.

5 Overview of the Appended Papers

This section briefly presents the papers appended to this thesis. A brief summary of the aim and the results of the studies presented in each paper is given.

5.1 Risk Preferences, Risk Perceptions and Timber Harvest Decisions – An Empirical Study of NIPF Owners in Northern Sweden (Paper I)

The overall aim of the study presented in this paper was to determine to what extent the NIPF owners' harvesting behaviour was consistent with their preferences and subjective judgments. The paper describes the respondents' risk preferences as well as their perceptions of the return and risk of timber investment relative to investment alternatives outside forestry. We also wanted to examine how the decision to conduct final felling related to the preferences for risk and the subjective judgments of the financial risk and return.

Central for these analyses were responses to two questions in the mail survey. The first asked the NIPF owners to state their views of the expected return from, and financial risk associated with, three alternative investments, compared to leaving a mature stand unharvested. The three alternative investments were investments in an ordinary bank account, a forest account[vii] and stocks/bonds. The second survey question of central importance was the question designed to elucidate the respondents' preference for risk-taking. Although the scenario in this question and the response alternatives were constructed to allow respondents to express a risk-seeking option, our expectation was that a majority would indicate aversion to

risk-taking. However, most of the NIPF owners chose the risk-neutral and risk-seeking alternatives.

The results revealed that subjective judgements NIPF owners made about expected returns from the investment alternatives vary greatly. This was also true for their judgements about the risk. The analysis further revealed that the preference for risk had a significant impact on decisions to conduct final felling. The NIPF owners who indicated that they were neutral to the financial risk-taking were more likely to have conducted final felling than those who were averse to the risk, and those who indicated that they were risk-seeking were even more likely to have conducted felling. Table 3 shows the proportions of owners in the respective groups that had conducted felling (active owners). Correlations between the respondents' attitudes to the risk and some property characteristics were also analysed. We found no statistically significant correlations between attitudes to risk and the size of forest property or the growing stock of timber.

Table 3. *Number of respondents, average size of forest, and the proportions of active owners in indicated risk-preference groups.*

	Risk-averse	Risk-neutral	Risk-prone	Unsure	Whole sample
Number of respondents	148	224	365	184	921
Proportion of active owners (%)	52.0	56.7	67.1*	45.7*	57.9
Proportion of owners who plan to fell in coming 3 years (%)	55.3	48.9	51.7	34.1*	48.1

* Indicates statistically significant differences from overall means, at the 5 % probability level.

The analysis of the harvesting decisions of groups formed according to investment preferences showed that owners whose preferred investment alternative was the mature forest harvested significantly less actively, on average, than owners with other preferred investment alternatives.

As described in the method section, there were two questions that were intended to reveal attitudes to risk. The joint analysis of responses to these two survey questions revealed a rather high degree

of inconsistency. Many respondents who indicated a preference for the offered price to avoid the uncertainty of waiting showed no willingness to pay for the risk reduction and many of the risk-seeking owners asked for a price that was beyond the range that the future price was said to have. Overall, the examination of NIPF owners' harvesting behaviour, risk preferences and subjective judgments revealed strong indications that NIPF owners find it difficult to make rational decisions when faced with uncertainties.

5.2 Do Owner and Property Characteristics affect Non-industrial Private Forest Owners' Attitudes to Risk? (Paper II)

In the study presented in this paper the aim was to examine if (and if so how) characteristics of NIPF owners and their properties affect the owners' preference for financial risk-taking in forestry decisions. It was hypothesised that the preference for risk-taking might be an underlying mechanism through which owner and property characteristics affect management decisions.

Using a two-period model it was discussed how attitudes to risk-taking, as measured by the NIPF owners' willingness to pay for risk reduction, can be incorporated into the utility function of a NIPF owner. However, since willingness to pay for risk reduction was not observable in the data, for the empirical analysis an index describing the NIPF owners' preference for risk was created from the responses to the hypothetical question concerning the respondents' preference for financial risk in forestry decisions.

The results of the probit analysis revealed that owner and property characteristics do affect the respondent's attitude to risk. From Table 4 it can also be seen how these characteristics affected the respondents' attitude to financial risk, e.g. the 'sex' coefficient reveals that female owners were more likely to indicate a risk-seeking attitude than male owners. An owner who had frequently visited their forest for silvicultural work was more likely to be risk-seeking than an owner who had visited it less frequently. The results support the hypothesis that attitudes to risk influence the relationship between characteristics and management decisions, and thus help to explain the many previous findings that characteristics do affect management decisions. The

results further indicate that owner characteristics might be more important in the formation of risk preferences than property characteristics. Some results of the study were expected, for instance that increased length of ownership increases the probability that an owner is averse to risk, while others were unexpected, e.g. that females are more likely to be prone to risk-taking compared to male owners. The unexpected results may be regarded as indications of the difficulties of elucidating risk preferences, and raise new questions about why females apparently indicated different attitudes to risk compared to males. A conceivable reason for this is a difference between the sexes in regarding forestry as a business, due to differences between them in terms of how their forest properties have been acquired, if the mode of acquisition affects business orientation and risk management.

Table 4. *Summary of results of the ordered probit regression.*

Variable		Coefficient	Standard error	P-value
		(n=682)		
	Constant	0.8178***	0.1549	0.000
	Ownership length (years)	-0.0087**	0.0038	0.022
	Forest visits	0.133***	0.0424	0.002
	Hectare	0.0003	0.00032	0.141
Dummy-variables				
	Sex (1=male, 0=female)	-0.2083*	0.1090	0.056
	Member (1=yes, 0=no)	0.1088	0.0941	0.247
	House (1=yes, 0=no)	-0.0220	0.1135	0.846
MU(2)		0.8920***	0.0539	0.000
Log likelihood function		-686.75		
Restricted log likelihood		-696.94		
Likelihood ratio		20.37	0.002	

* Significant at the 10 % probability level
** Significant at the 5 % probability level
*** Significant at the 1 % probability level

This study provided knowledge of an important link that had been neglected in previous examinations of the relationships between owner and property characteristics to management decisions, namely

the formation of attitudes toward risk, and a new approach for assessing the relationships. These are important steps in linking characteristics to management decisions that warrant further research. The relationship found between characteristics and attitudes to risk-taking in this study is useful in several ways.

5.3 Non-industrial private forest owners' financial risk taking – Does gender matter? (Paper III)

The aim of this study was to discuss the findings from the previous study about women's higher willingness to take risks compared to men's, from a gender perspective. A risk tolerance index (RTI) was formed from responses to the survey question about attitude to the hypothetical timber sales contract and the mean RTI was calculated for subgroups formed according to gender, dependence on income from forestry and the objective of obtaining economic yield from forestry.

The mean RTI over the whole sample indicated a strong tendency for the respondents to take the financial risk. A comparison of the mean RTI values for men and women show that the two groups had similar attitudes to the risk-taking. After adding the layer of financial dependency of income from forestry, another pattern emerged. When the financial dependency was insubstantial, men and women still showed similar attitudes to the risk-taking but when the financial dependency was notable women's willingness to take the financial risk increased, while men's willingness tended to decrease. In the final step, which considered whether the respondents had prioritized the economic contribution of forestry, the results from step two were basically unchanged. Four findings were formulated:

Finding 1: Women and men are willing to take similar risks if their household's financial dependence on forestry is insubstantial.

Finding 2: Women are more willing than men to take risks if their household's financial dependence on forestry is notable.

Finding 3: Women's willingness to take risks increases with increasing financial dependence on forestry.

Finding 4: Men's willingness to take risks tends to slightly decline with increasing financial dependence on forestry.

It can be argued that for NIPF owners who have a low dependency on forestry income, there is a lack of incentives to engage in forest management and that a low engagement, shared by men and women, could partly explain why no significance difference between the two groups in willingness to take risks was found at this level of dependency. In contrast, an owner who has a higher dependency on income from forestry would be more interested in maintaining his or her financial security and therefore less willing to take risks. Men followed this prediction by showing a tendency to be less willing to take risk when a notable portion of their income came from forestry. But why didn't women? A possible explanation that is considered in this paper is that female owners acquire their properties through legacies to a greater extent than men, while men buy their properties to a greater extent than women, and buyers could have a greater tendency to regard their forests as business projects, while inheritors could regard their forests more as bonus income.

However, the above argument does not explain why women's willingness to take risks appears to increase with increasing financial dependence on forestry. On the other hand, if a female forest owner inherited her property, social and cultural perspectives within forestry (gendered forestry) may prompt her to consider herself to be a transitive element, waiting to withdraw for a man. If such a female delays making a decision about felling timber, especially if large sums of money are involved, it might not be because she is liable to take risks, but rather because she is a transitive element, waiting for a man to take the decisions in the future. That is, our conclusion that women are inclined to take risks may not be a correct interpretation of our results.

The study presents interesting differences between male and female NIPF owners and suggests that the common view that women have a lower level of risk tolerance than men might be an over-simplification. Other factors, such as those examined in this study, also affect risk tolerance, but may have differing effects on men and women. It should be noted that the statistical significance of between-sex differences in willingness to take risks found in this study is low, thus they should be interpreted with care. However, the paper contributes to the discourse by discussing the indicated differences from a gender perspective

Regardless of the underlying cause(s) of our observed differences, the study supports the idea that management decisions and practices that men and women apply to forests they own differ substantially.

5.4 Effects of Owner and Property Characteristics on Non-industrial Private Forest Owners' Objectives (Paper IV)

The aim of the study presented in this paper was to model how owner and property characteristics affect individual objectives of ownership held by NIPF owners. First, a multivariate probit regression model was used to test whether there were strong correlations between the error terms of this regression. The purpose of this analysis was to determine whether the objectives should be modelled jointly, or if they could be modelled separately. The results suggested that the effects of owner and property characteristics on each objective could be modelled separately.

The most frequently prioritized objective of ownership was maintaining a tradition of forestry within the family. The results show that a male owner has a significantly lower likelihood of prioritizing the tradition of forestry compared to a female owner. Overall, the NIPF owner's sex was found to be an influential characteristic for most of the ownership objectives considered in this study. It significantly influenced whether or not hunting opportunity was a prioritized objective. Being a male significantly increased the likelihood that the forest owner would list hunting opportunity as a prioritised objective. For the likelihood of prioritizing recreation (other than hunting) the effect of sex was equally strong as for hunting, but with the opposite sign. Hence, being a female significantly increased the likelihood that the forest owner would prioritize the recreational opportunities. Older owners and members of a NIPF owner association were also more likely to prioritize this objective compared to younger owners and non-member owners, respectively.

The results also show that an older NIPF owner had a lower likelihood of prioritizing an economic contribution from forestry than a younger owner, and the more owners there were of a forest property, the less likely a respondent was to prioritize this objective, while increases in the area (hectares) of forest land owned increased the likelihood. The last finding is consistent with previous findings that propensity to harvest is positively correlated with the area of

forestland owned. It is worth noting that the owner's sex did not significantly affect the prioritization of this objective. The results also indicate that except for an interest in aesthetic surroundings around the house, the objectives of owners who had a house on their property did not differ significantly from those not having any house on their property.

The approach of this study was straightforward in that it directly linked individual characteristics to individual objectives. The findings are important as the objectives of ownership are important links between owner and property characteristics and NIPF owners' management decisions. The results might help to explain underlying reasons for findings in previous investigations, e.g. the decreasing probability of having an economic objective with increasing age might help to explain the decline in harvesting propensity with age found by authors such as Kuuluvainen (1989), Carlén (1990), Lidestav and Ekström (2000), Joshi and Arano (2009).

6 Concluding Discussion

The main objective of the studies this thesis is based upon was to develop a better understanding of factors underlying the effects of owner and property characteristics on NIPF owners' management decisions. Particular attention has been devoted to their effects on owners' attitude to financial risk and how this attitude affects decisions to harvest timber.

Elucidation of the respondents' willingness to take financial risk is essential to enable the inclusion of risk preference in analyses of NIPF owners' management behaviour. However, before the survey was undertaken it was expected that most NIPF owners would be averse to risk-taking. The findings that so many were risk-neutral and even more (nearly 40%) were risk-seeking deserves some comment, since substantially lower proportions of risk-seekers have been found in other analyses of individuals' risk attitude. For instance, in a sample surveyed by Holt and Laury (2002) 8 to 15 % were found to be risk-seeking individuals, and Harrison et al. (2007) found Danes to be clearly risk-aversive, generally, and very few subjects of their subjects were risk-loving or risk-neutral. Could one conclude from this that NIPF owners are different from the general population in terms of risk attitude? Apart from assuming that people operating their own business, as NIPF owners do, are less risk-averse than people in general, the answer is probably to be found in the design of our survey. In the survey question, only a unit price per cubic metre was mentioned. It is therefore possible that some respondents regarded this unit price as the total amount at stake, and they might have indicated a high willingness to take risk in accordance with expectations that willingness to take risk is generally higher when the amount at stake is low. The results may have shown a higher level of

risk aversion if the hypothetical question had also indicated the size of timber sales contracts. If the amount at risk was considered low, the large proportion of NIPF owners being risk-seeking would be consistent with findings of Lönnstedt & Svensson (2000), who also found that NIPF owners showed decreasing absolute and relative risk aversion. Another factor indicating that the low risk aversion detected was correct is the low dependency on forestry income among the NIPF owners considered in this study. Even though the ownership objective of obtaining an economic contribution for the household from forestry was one of the most prioritized objectives, the dependency on income from forestry was generally low among the respondents. A low dependency on income from forestry was also found in Mattsson et al. (2004) and Ingemarson et al. (2006).

The inclusion of two questions in the survey designed to reveal NIPF owners' willingness to accept risk allowed the consistency in their answers concerning risk to be assessed. The first of these two questions offered a choice between three pre-specified alternatives (four including "don't know"), whereas in the second the respondent was asked to state an amount. Therefore, the second can be regarded as the harder one of the two to answer. Rather high inconsistency between responses to the two questions was found, at least according to our interpretation. Failure of a respondent to give a reasonable answer when asked to state an amount does not mean that he/she did not know the true answer to the first question, but inconsistency between responses to the two questions strongly indicates that the respondent was uncertain about the answers to both questions, or that he/she answered the questions in an arbitrary manner. The large proportion of respondents who did not answer the questions consistently illustrates the difficulty that NIPF owners have to make rational decisions under uncertain conditions.

However, it should be mentioned that there is a less strict way of interpreting the responses to the second of the two questions that would increase the consistency. If all of the respondents understood the question as intended, and accepted that the future market price would definitely lie in the given interval, it would not make any sense for any NIPF owner to accept or request any price outside the bounds. However, if a respondent did not think that the specified price interval was credible, it is possible that he or she would state a lowest acceptable price that was even lower than the lower bound. Hence, although the responses to the two questions were inconsistent at first

glance, it is still possible that risk-averse owners who stated lower acceptable amounts than the lower bound of the price interval did answer the two questions consistently. Similarly, a risk-seeking owner asking for a price higher than the upper bound of the price interval would not necessarily have been inconsistent. For the analysis in the article published in Paper I, however, the more restrictive interpretation of the consistency was chosen.

It should also be mentioned that one problem that might arise when empirically studying individuals' attitude to risk is that the attitude might be domain-, or context-specific. Domain-specificity means that a respondent might indicate a risk-seeking attitude when faced with questions in one content area, and a risk-aversive attitude when faced with questions in another content area. One problem with certainty equivalent type questions, such as those used in the studies this thesis is based upon, is that they have been found to exaggerate risk aversion for gains and risk-seeking for losses (e.g. Schoemaker, 1990). Weber et al. (2002) tested a psychometric approach and studied risk-taking in five content domains and found that the attitude to risk-taking was highly domain-specific. They also found that women were more risk-averse, in all domains except the social domain. This problem should be kept in mind and one should generalise the results presented in this thesis to a wider area than the domain specified through the survey questions very cautiously.

In summary, there is room for improving the question formulation, but the investigation of the owners' preferences for risk contributes a promising way of including more explanatory variables in studies of forest owners' management behaviour.

The assessments of the return and risk of the mature forest relative to alternative investments varied widely among the respondents, indicating that there may be equally wide variation in harvesting behaviour. A large proportion of the NIPF owners assessed their return from the mature forest as higher than those from the alternative investments. Given that the growth of biomass in a mature forest is relatively slow, an appreciation of the financial performance of this investment alternative can be interpreted as being based on a strong belief that timber prices would rise in the coming years, or perhaps a justification for not investing the time and effort required to have the mature stands harvested. Concerning the judgements of risk, no definition of the term risk was given to the NIPF owners in the survey since the interest was in effects of what he/she perceived as risk.

However, given the way the hypothetical question about timber sales contracts was formulated, it should have been clear to the respondent that it concerned financial risks.

The results from the study of how management decisions are affected by judgments of risk and return indicate that preference for mature forest as an investment increases the length of the intervals between. It was further found that risk-averse owners tend to prefer to keep capital in the mature forest to a greater extent than the other risk preference groups, while risk-neutral and risk-prone owners tend to move capital to some alternative investment to a greater extent. The findings that attitudes to risk can affect management decisions generally, and more specifically how they can affect harvesting decisions, may be useful as complementary explanations to other previously reported relationships between owner and property characteristics and management behaviour. For instance, the survey results indicate that older owners have a higher probability to have the mature forest as their preferred investment. This could be an additional explanation to previous findings that older NIPF owners harvest less timber compared to younger ones (see, for instance Kuuluvainen 1989; Carlén 1990; Løyland et al. 1995; Lidestav and Ekström 2000; Bolkesjø et al. 2002; and Joshi and Arano 2009).

The finding shows that attitudes to risk affect behaviour and that empirical studies on NIPF owners' management behaviour can benefit from considering different attitudes to risk. With high quality data, attitudes to risk can be used to explain previous findings from such studies about NIPF owners' management behaviour.

As mentioned above, this is not the first study to consider NIPF owners' objectives of ownership. For instance, Kurtz and Lewis (1985), Karppinen (1998) and Ingemarson et al. (2006) have made valuable contributions to knowledge of the decision process. However, in previous studies owners were clustered into groups with similar objectives or motivations. This allows analysts to examine characteristics that members of each group share robustly, but there are often a number of respondents "left over" who do not seem to fit into any of the specified groups. In contrast, in the approach used here, the probit modelling directly models the relationship between individual characteristics and objectives. The analysis of the multivariate probit regression supports the idea that this can be done without considering other objectives that the respondents have prioritized. However, it should be emphasised that the survey

respondents could choose at most three objectives. This approach contributes by providing a way to examine effects of individuals' characteristics that are easy to generalise to larger groups of owners. That is not to say, as pointed out, e.g. by Karppinen (1998) and Ingemarson et al. (2006), that it would be appropriate to separate objectives of individual owners and assume that one can regard the owners as having single objectives.

The results from the study on whether gender affects risk attitudes of owners with different levels of financial dependence on forestry income should be interpreted with care, for several reasons. Firstly, the survey was not originally designed for such an analysis, (consequently) there were fewer females than males in the sample. Secondly, the level of significance of between-gender differences in risk attitudes was weak. However, the paper contributes by discussing gender-related aspects, and providing at least some indications of ways in which gender may affect forestry decisions and that concluding that one gender is always more risk-averse than the other is a simplification. Again, domain-specificity is also important, in accordance with the finding of Weber et al. (2002) that women are more risk-seeking than men in the social domain.

As for the findings regarding the effects of attitude to risk, the findings from the modelling of NIPF owners' ownership objectives may also be helpful in explaining results from previous empirical studies. Once again, the finding mentioned above by previous authors, e.g. Kuuluvainen (1989), that older NIPF owners harvest less timber compared to younger ones, can be further explained by results from this study: older owners have a lower probability of prioritizing the objective of economic yield from their forestry. Another example is the results concerning the area of productive forestland. The increased probability that owners with large forest areas will have economic objectives for their forest is consistent with findings of various authors (e.g. Kuuluvainen 1989; Carlén 1990; Lidestav and Ekström 2000; and Conway et al. 2003) that increasing the area of forestland increases the probability of timber harvesting.

Policy implications

The study of how owner and property characteristics influence risk preferences and the objectives of ownership points to important links between the owner and his or her decisions. Knowledge of these

underlying mechanisms is important for understanding the management decisions made by NIPF owners.

Elucidation of respondents' attitude to risk is essential for including risk attitudes in analyses of NIPF owners' management behaviour. The investigation of owners' attitudes to financial risk provides a promising way of including more explanatory variables in studies of forest owners' behaviour.

The results presented in this thesis add further support to the idea that the management decisions and practices that women and men apply to forests they own differ. One difference, with potential roots in gender structures and highlighted through their revealed willingness to take risk, has been discussed.

Through information and education the NIPF owners can become more aware of the risks associated with forestry. Such awareness would facilitate the forest owners' adaptation of their management practices to the desirable level of risk exposure. The results presented here indicate that at present NIPF owners generally find it to difficult to incorporate risks into their planning, at least as far as the financial risk considered here is concerned.

For organisations interacting with individual forest owners, e.g. NIPF owner associations, the results presented in this thesis suggest that consideration of the owners' willingness to take financial risk could be included in economic consultations. NIPF owners associations might also more clearly acknowledge that their members have economic yield and timber production objectives to a greater extent than NIPF owners in general, and in that sense their members might not be representative of all NIPF owners today. This indication is in line with the conclusions of Berlin et al. (2006).

Further research

To my knowledge, very few studies have empirically examined NIPF owners' attitudes to financial risk-taking in forestry and related them to the effects they have on forest management practices. However, the results presented here indicate that it is beneficial to include them, and improving their incorporation would strengthen models of their behaviour. It would be of interest to investigate further the relationships between the subjective judgements that NIPF owners make of alternative investments and their decision-making. The reliability of the subjective judgements of risks involved could be in the

interest of future study. In the studies underlying this thesis there were no comparisons of real (objectively measured) risks and subjective judgements of risks.

The detected inconsistency in NIPF owners' statements about their willingness to take financial risk calls for further development of the method for elucidating those preferences. However, I believe that questions intended to probe them should retain a timber sales-related setting to ensure accuracy, since preferences for risk are, as Hanoch et al. (2006) pointed out, both domain- and situation-specific.

The study of how owner and property characteristics affect NIPF owners' attitudes to risk, ownership objectives and ultimately their management behaviour, indicates that variations in these traits will lead to diversity in both managerial approaches and forest conditions. This indicates a need to further develop theoretical models that allow for different preferences and objectives, and frameworks that acknowledge the importance of subjective judgements. More detailed information on how NIPF owners reason in the face of financial risk and when making decisions about postponing harvests of mature stands is also needed.

References

Ahti, T., Ahit-Hämät, L. and Jalas, J. (1968) Vegetation Zones and their Sections in Northwestern Europe. *Annales Botanici Fennici* 5, 169-211.

Alvarez, L.H.R., and Koskela, E. (2006) Does Risk Aversion Accelerate Optimal Forest Rotation under Uncertainty? *Journal of Forest Economics* 12, 171-184.

Amacher, G.S., Conway, M.C. and Sullivan, J. (2003) Econometric Analysis of Nonindustrial Forest Landowners: Is there anything left to study? *Journal of Forest Economics* 9, 137-164.

Arrow, K. (1965) Aspects of the Theory of Risk-Bearing. Helsinki, Yrjö Johanssonin Säätiö.

Beach, R.H., Pattanayak, S.K., Yang, J-C., Murray, B.C. and Abt, R.C. (2005) Econometric Studies of Non-industrial Private Forest Management: a review and synthesis. *Forest Policy and Economics* 7, 261-281.

Berlin, C., Lidestav, G. and Holm, S. (2006) Values Placed on Forest Property Benefits by Swedish NIPF owners: Differences between Members in Forest Owner Associations and Non-members. Small-scale Forest Economics, Management and Policy 5(1), 83-96.

Binkley, C.S. (1981) *Timber Supply from Private Non-industrial Forests*. Yale University Press, New Haven.

Blennow, K. and Sallnäs, O. (2002) Risk Perception Among Non-industrial Private Forest Owners. *Scandinavian Journal of Forest Research* 17, 472-479.

Bolkesjö, T.F. and Baardsen, S. (2002) Roundwood Supply in Norway: micro-level analysis of self-employed forest owners. *Forest Policy and Economics* 4, 55-64.

Bolkesjö, T.F., Solberg, B. and Wangen, K.R. (2007) Heterogeneity in Nonindustrial Private Roundwood Supply: Lessons from a large panel of forest owners. *Journal of Forest Economics* 13, 7-28.

Brazee, R. and Mendelsohn, R. (1988) Timber Harvesting with Fluctuating Prices. *Forest Science* 34, 359–372.

Calish, S., Fight, R.D. & Teeguarden, D.E. (1978). How do Non-timber Values Affect Douglas-fir Rotations? *Journal of Forestry* 76, 217-221.

Carlen, O. (1990) Private Nonindustrial Forest Owner's Management Behavior: An economic analysis based on empirical data*. Department of Forest Economics, Swedish University of Agricultural Sciences*. Report No 92.

Clarke, H.R. and Reed, W.J. (1989) *The Tree-cutting Problem in a Stochastic Environment – The case of age-dependent growth*. Journal of Economic Dynamics and Control 13, 569-595.

Conway, C., Amacher, G.S., Sullivan, J. and Wear, D. (2003) Decisions Nonindustrial Forest Landowners make: an empirical examination. *Journal of Forest Economics* 9, 181-203.

Dennis, D.F. (1989) An Economic Analysis of Harvest Behavior: Integrating Forest and Ownership Characteristics. *Forest Science* 35 (4), 1088-1104.

Englin, J. (1990) Backcountry Hiking and Optimal Timber Rotation. *Journal of Environmental Management* 31, 97-105.

Faustmann, M. (1849) Berechnung des Wertes welchen Waldboden sowie noch nicht haubare Holzbestände für die Waldwirtschaft besitzen. *Allgemeine Forst- und Jagd-Zeitung*, 15. In German.

Favada, I.M., Karppinen, H., Kuuluvainen, J., Mikkola, J. and Stavness, C. (2009) Effects of Timber Prices, Ownership Objectives, and Owner Characteristics on Timber Supply. *Forest Science* 55 (6), 512- 522.

Friedman, M. and Savage, L.J. (1948) The Utility Analysis of Choices Involving Risk. *The Journal of Political Economy* 56 (4), 279-304.

Gong, P. (1999) Optimal Harvest Policy with First-order Autoregressive Price Process. *Journal of Forest Economics* 5, 413–439.

Gong, P. (1998) Risk Preferences and Adaptive Harvest Policies for Even-aged Stand Management. *Forest Science* 44 (4), 496-506.

Gong, P., and K-G. Löfgren. (2008) Impact of Risk Aversion on the Optimal Rotation with Stochastic Price. *Natural Resource Modeling* 21, 385-415.

Gong, P. and Löfgren, K-G. (2003) Risk-Aversion and the Short-Run Supply of Timber. *Forest Science* 49 (5), 647-656.

Gong, P., Boman, M. & Mattsson, L. (2005) Non-timber Benefits, Price Uncertainty and Optimal Harvest of an Even-aged Stand. *Forest Policy and Economics* 7, 283-295.

Greene, W.H. (2008). Econometric Analysis. 6th Edition. New Jersey, USA. Prentice Hall.

Hanoch, Y., Johnson, J.G. and Wilke, A. (2006) Domain Specificity in Experimental Measures and Participant Recruitment – An Application to Risk-Taking Behavior. *Psychological Science* 17 (4), 300-304.

Harrison, G.W., Lau, M.I. and Rutstrom, E.E. (2007) Estimating Risk Attitudes in Denmark: A Field Experiment. *Scandinavian Journal of Economics* 109(2), 341-368.

Hartman, R. (1976) The Harvesting Decision when a Standing Forest has Value. *Economic Inquiry* 14, 52-58.

Holt, C. and Laury, S. (2002) Risk Aversion and Incentive Effects. *American Economic Review* 92(5), 1644-1655.

Huang, C-H. and Kronrad G.D. (2006) The Effect of Carbon Revenues on the Rotation and Profitability of Loblolly Pine Plantations in East Texas. *Southern Journal of Applied Forestry* 30 (1), 21-29.

Ingemarson, F., Lindhagen, A. and Eriksson, L. (2006) A Typology of Small-scale Forest Owners in Sweden. *Scandinavian Journal of Forest Research* 21 (3), 249-259.

Johansson, P.O. and Löfgren, K-G. (1985) *The Economics of Forestry and Natural Resources*. Basil Blackwell, Oxford.

Joshi, S. and Arano, K.G. (2009) Determinants of Private Forest Management Decisions: A study on West Virginia NIPF landowners. *Forest Policy and Economics* 11, 118-125.

Karppinen, H. (1998) Values and Objectives of Non-industrial Private Forest Owners in Finland. *Silva Fennica* 32 (1), 43-59.

Koskela, E. (1989) Forest Taxation and Timber Supply Under Price Uncertainty: Perfect Capital Markets. *Forest Science* 35, 137-159.

Koskela, E. and Ollikainen, M. (1997) Optimal Design of Forest Taxation with Multiple-Use Characteristics of Forest Stands. *Environmental and Resource Economics* 10, 41-62.

Kriström, B. & Skånberg, K. (2001) Monetary Forestry Accounting Including Environmental Goods and Services. *Investigacion Agraria Sistemas y Recursos Forestales*. Fuera de Serie N1-2001.

Kurtz, W.B. and Lewis, B.J. (1981) Decision-making Framework for Nonindustrial Private Forest Owners: An application in the Missouri Ozarks. *Journal of Forestry* 79, 285-288.

Kuuluvainen, J., Karppinen, H. and Ovaskainen, V. (1996) Landowner Objectives and Nonindustrial Private Timber Supply. *Forest Science* 42 (3), 300-309.

Kuuluvainen, J. (1990) Virtual Price Approach to Short-Term Timber Supply under Credit Rationing. *Journal of Environmental Economics and Management* 19, 109-126.

Kuuluvainen, J. (1989) Nonindustrial Private Timber Supply and Credit Rationing – Microeconmic foundations with empirical evidence from the Finnish case. Department of Forest Economics, Swedish University of Agricultural Sciences. Report No 85.

Kuuluvainen, J. and Tahvonen, O. (1999) Testing the Forest Rotation Model: Evidence from Panel Data. *Forest Science* 45 (4) 539-551.

Lidestav, G. (2010) In Competition with a Brother - Women's inheritance position in contemporary Swedish family forestry. *Scandinavian Journal of Forest Research (in press).*

Lidestav, G. (1998) Women as Non-industrial Private Forest Landowners in Sweden. *Scandinavian Journal of Forest Research* 13 (1), 66-73.

Lidestav, G. and Ekström, M. (2000) Introducing Gender in Studies on Management Behaviour Among Non-industrial Private Forest Owners. *Scandinavian Journal of Forest Research* 15, 378-386.

Lohmander, P. (1987) The economics of Forest Management under Risk. Department of Forest Economics, Swedish University of Agricultural Sciences. Report No 79.

Lönnstedt, L. and Svensson, J. (2000) Non-industrial Private Forest Owners' Risk Preferences. *Scandinavian Journal of Forest Research* 15, 651-660.

Mattsson, L., Boman, M. and Kindstrand, C. (2004). Privatägd skog: Värden, visioner och forskningsbehov. Rapport SUFOR/Brattåsstiftelsen. (in Swedish.)

Löyland, K., Ringstad, V. and Öy, H. (1995) Determinants of Forest Activities – A Study of Private Nonindustrial Forestry in Norway. *Journal of Forest Economics* 1(2), 219-237.

Mattsson, L. and Li, C-Z. (1994) How do Different Forest Management Practices Affect the Non-timber Value of Forests? – an Economic Analysis. *Journal of Environmental Management* 41, 79-88.

Mattsson, L. and Stridsberg, E. (1981) Skogens roll i Svensk markanvändning- En utvecklingsstudie. Department of Forest Economics, Swedish University of Agricultural Sciences. Report No 32 b. In Swedish.

Max, W. and D.E. Lehman (1988) A Behavioral Model of Timber Supply. *Journal of Environmental Economics and Management* 15, 71-86.

Neumann, J. von and Morgenstern, O. (1944) *Theory of Games and Economic Behavior.* Princeton, Princeton University Press.

Newman, D.H., Gilbert, C.B. and Hyde, W.F. (1985) The Optimal Forest Rotation with Evolving Prices. *Land Economics* 61(4), 347-353.

Ní Dhubháin, Á., Cobanova, R., Karppinen, H., Mizaraite, D., Ritter, E., Slee, B. and Wall, S. (2007) The Values and Objectives of Private Forest Owners and Their Influence on Forestry Behaviour: The Implications for Entrepreneurship. *Small-scale Forestry* 6, 347-357.

Norstrom, C.J. (1975) A Stochastic Model for the Growth Period Decision in Forestry. *Swedish Journal of Economics* 77, 329–337.

Ollikainen, M. (1993) A Mean-Variance Approach to Short-Term Timber Selling and Forest Taxation Under Multiple Sources of Uncertainty. *Canadian Journal of Forest Research* 20, 1823-1829.

Ollikainen, M. (1991) The Effect of Nontimber Taxes on the Harvest Timing – The Case of Private Nonindustrial Forest Owners: A Note. *Forest Science* 37 (1), 356-363.

Ollikainen, M. (1990) Forest Taxation and the Timing of Private Nonindustrial Harvests under Interest Rate Uncertainty. *Canadian Journal of Forest Research* 20, 1823-1829.

Pennings, J.M.E. and Smidts, A. (2000) Assessing the Construct Validity of Risk Attitude. Management Science 46(10), 1337-1348.

Pindyck, R.S. and Rubinfeld, D.L. (1991) *Econometric Models and Economic Forecasts*. 3rd edition. McGraw-Hill, New York.

Pratt, J.W. (1964) Risk-Aversion in the Small and in the Large*. Econometrica* 32 (1-2), 122-136.

Raunikar, R. and Buongiorno, J. (2006) Willingness to Pay for Forest Amenities: The case of non-industrial owners in the south central United States. *Ecological Economics* 56, 132-143.

Reed, W.J. (1984) The Effects of the Risk of Fire on the Optimal Rotation of a Forest. *Journal of Environmental Economics and Management* 11, 180-190.

Romm, J., Washburn, C., Tuazon, R. and Bendix, J. (1987). Public Subsidy and Private Forest Investment: Analyzing the Selectivity and Leverage of a Common Policy Form. *Land Economics* 63 (2), 153-167.

Samuelson, P.A. (1976) Economics of Forestry in an Evolving Society. *Economic Inquiry* 14, 466-492.

Scarpa, R., Chilton, S.M., Hutchinson, W.G. and Buoungiorno, J. (2000) Valuing the Recreational Benefits from the Creation of Nature Reserves in Irish Forests. *Ecological Economics* 33, 237-250.

SCB (2010) *Statistical Yearbook 2010*. Stockholm, Statistics Sweden.

Schoemaker, P.J.H. (1990) Are Risk-preferences Related across Payoff Domains and Response Modes? *Management Science* 36, 1451-1463.

Skogsstyrelsen (2009) *Skogsstatistisk årsbok*, Jönköping. Skogsstyrelsen

Snyder, D.L. and Bhattacharyya, R.N. (1990). A More General Dynamic Economic Model of the Optimal Rotation of Multiple-Use Forests. *Journal of Environmental Economics and Management* 18, 168-175.

Stordal, S., Lien, G. and Hardaker, JB. (2007) Perceived Risk Sources and Strategies to cope with Risk among Forest Owners with and without Off-property Work in Eastern Norway. *Scandinavian Journal of Forest Research* 22, 443-453.

Strange, N., Tarp, P., Helles, F. & Brodie, J.D. (1999) A Four-stage Approach to Evaluate Management Alternatives in Multiple-use Forestry. *Forest Ecology and Management* 124, 79-91.

Strang, W.J. (1983) On the Optimal Forest Harvesting Decision. *Economic Inquiry* 21, 576-583.

Swallow, S.K. and Wear, D.N. (1993) Spatial Interactions in Multiple-Use Forestry and Substitution and Wealth Effects for the Single Stand. *Journal of Environmental Economics and Management* 25, 103-120.

Tahvonen, O. and Salo, S. (1999) Optimal Forest Rotation with *in Situ* Preferences. *Journal of Environmental Economics and Management* 37, 106-128.

Taylor, R.G. and Fortson, J.C. (1991) Optimum Plantation Planting Density and Rotation age Based on Financial Risk and Return. *Forest Science* 37, 886-902

Uusivuori, J. (2002) Nonconstant Risk Attitudes and Timber Harvesting. *Forest Science* 48 (3), 459-470.

Valsta, L.T. (1992) A Scenario Approach to Stochastic Anticipatory Optimization in Stand Management. *Forest Science* 38 (2), 430-447.

Weber, E.U., Blais, A-R. and Betz, N.E. (2002) A Domain-specific Risk-attitude Scale: Measuring Risk Perceptions and Risk Behaviors. *Journal of Behavioral Decision Making* 15, 263-290.

Vokoun, M., Amacher, G.S. and Wear, D.N. (2006) Scale of Harvesting by Non-industrial Private Forest Landowners. *Journal of Forest Economics* 11, 223-244.

Wear, D.N. and Parks, P.J. (1994) The Economics of Timber Supply: An analytical synthesis of modelling approaches. *Natural Resource Modeling* 8 (3), 199-223.

Acknowledgments

First of all, I would like to express my gratitude to my main supervisor, prof. Peichen Gong. You have always had time for me and seem to have an endless patience when explaining difficult things and always have ideas for solutions when I do not see them. Your help has been invaluable. Further, I would like to thank my assistant supervisors, Mattias Boman and prof. Bengt Kriström who always are fast to send well thought-out answers to any questions I have sent.

I would also like to thank my colleagues at the department of Forest Economics. . I have enjoyed the friendships that have evolved over numerous cups of coffee through these years. My colleagues Cecilia Håkansson, Örjan Furtenback, Camilla Widmark, Pia Löthgren and Rune Simonsen have offered stimulating company in, as well as out of, office. I thank Göran Bostedt, Ola Carlén, Tommy Lundgren and Peter Lohmander for their help in pre-evaluating the papers of this thesis

I would like to thank friends and family for your support and for being there whenever I have needed to ease my mind with more uplifting things than piles of work. Finally, I want to thank my parents, Karin and Curt Andersson, for never having tried to stop me from following my own ideas.

[i] 28.4 million hectares according to the FAO definition (Skogsstyrelsen, 2009)

[ii] Ownership of shares in a forest company is not included in NIPF ownership.

[iii] These counties, together with a few other counties are commonly known as forest counties (skogslän).

[iv] Forestland within a single municipality that belongs to a single owner is regarded as a management unit (Skogsstyrelsen, 2009).

[v] Persons registered as contact persons, who were assumed to be the main decision-makers

[vi] For reasons discussed in chapter 23 in Greene (2008) linear regression in discrete modelling is inappropriate for several reasons.

[vii] A bank account enabling forest owners to reduce income tax from timber harvests